Modular Industrial Controller

MOACON

User's Manual

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* This manual is published in electronic format only.

"Everything for Embedded Control"

COMFILE TECHNOLOGY

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Introduction

The MOACON is a C-programmable modular industrial controller. Its modular design enables customers to purchase just the modules needed, and aggregate them in a way that customizes the MOACON precisely for a product's specific requirements, and provides adaptability should those requirements change.

MOACON's Primary Features

1. **Modular Design**
2. **C Programmable**
3. **32 bit ARM Processor**
4. **USB Downloading and Debugging**
5. **MOACON Studio - Free Integrated Development Environment (IDE) Software**

The MOACON boasts a 32-bit ARM CPU Module for fast and complex computation and data processing. Individual modules include features for **Digital I/O, Relay Output, Analog-to-Digital and Digital-to-Analog Conversion, Motor control, Temperature Monitoring, RS-232 Communication, Ethernet**, and the potential for more.

The free integrated development environment software, **MOACON Studio**, features a C compiler, source editor, RS-232 communication, USB downloading and debugging, and more. The source editor features syntax highlighting, command completion, and context sensitive help making learning, developing, and testing MOACON software projects a truly productive and enjoyable experience.

We hope that you find the MOACON's unique features and flexibility ideally suited for both your current and future projects.

Comfile Technology

Frequently Asked Questions

Q: What software is needed to use the MOACON?

You only need MOACON Studio. It is an integrated development environment that contains everything you need to program the MOACON. It can be downloaded from www.ComfileTech.com.

Q: I'm currently using Comfile Technology's CUBLOC. How is the MOACON different?

The CUBLOC is a microcontroller capable of simultaneous execution of both BASIC and Ladder Logic. The code is interpreted which, in comparison with the MOACON, results is a slower execution speed.

The CUBLOC is primary targeted for customers who wish to manufacture mass quantities of custom PCB products with the goal of reducing production costs.

The MOACON is a 32-bit ARM processor based, modular, C programmable controller. The code is compiled, rather than interpreted resulting in **much faster execution**.

Due to the MOACON's modular design, a variety of features, such as **Ethernet, temperature monitoring, digital-to-analog conversion, and more,** can be aggregated to customize the MOACON for a specific product's requirements or added at a later time as a product's requirements change.

Q: What's the maximum number of digital I/O ports supported by the MOACON?

Used in combination with the I/O Expansion Modules, the MOACON can support up to 256 ports

- 48 Default Digital I/O Ports
- 128 Expandable Digital Input Ports
- 80 Expandable Relay Output Ports

Q: Is multitasking supported?

Multitasking is not supported, but using timers, background processing can be simulated.

Q: What is needed to get started using the MOACON?

The MOACON START PACK contains everything that is needed to get started and should be purchased first. Additional modules can be purchased separately to fulfill any remaining requirements.

START PACK Contents:

- MOACON CPU Module: DP-CPU500
- 8-Pin Digital Input Module: CF-DIDC8
- 8-Pin Digital Output Module: CF-DORL8
- 10-Slot Module Base
- Power Supply: 24VDC 0.62A Output
- Power Cable
- Wire
- USB Download Cable

Table of Contents

Chapter 1 MOACON Overview **10**
MOACON Studio 11
CPU Module 12
Modules 13
Module Board 14
Installing General DIO Modules 15
Installing Expansion DIO Modules 17
Installing Analog Modules 20
Installing Special Purpose Modules 21
Installing Motion Control Modules 22
Module Installation Summary 23
Special Purpose Modules 23
Digital IO Modules 23
Analog Modules, Motion Control Modules, Expansion Digital I/O Modules 23
Small System Configuration 24
Chapter 2 Setup **26**
MOACON CPU Module 27
DP-CPU500 Specifications 27
Installation 28
Supplying Power 29
Surge Killer 30
Power Relay Wiring 31
Relay Power Wiring 32
Software Installation 34
Chapter 3 Programming the MOACON **42**
MOACON Studio 43
Creating a Project 44
Compiling and Executing a Project 46
Compiler Errors 49
Adding Source Files to a Project 50
Debug Terminal 52
debugCls *52*
debugLocate *52*
debugPut *52*
printf *52*
Data Types 54
Memory 55
Chapter 4 System Library **56**
delay *57*
statusLed *58*
Real-Time Clock 59
rtcRead *60*
rtcWrite *60*
FRAM Functions 61
framWrite *61*
framRead *61*
Watchdog Timer 63

wdtOn 63
wdtClear 63
Timer 65
startTimerEvent 65
timerEvent 65
stopTimerEvent 66
External Interrupts 67
startExtIntEvent 67
extIntEvent 68
stopExtIntEvent 69
Chapter 5 Digital I/O Modules 70
Source and Sink Outputs 71
8-Port DC Source Output Module 71
CF-DOSO8 Specifications 71
8-Port DC Sink Output Module 72
CF-DOSI8 Specifications 72
8-Port Relay Output Module 73
CF-DORL8 Specifications 73
Digital Output Module Library 74
portInit 74
portOut 76
portBlockOut 76
portOff 76
portOn 76
portReverse 77
portOutStat 77
8-Port Digital Input Module 78
Digital Input Module Library 79
portIn 79
portBlockIn 79
16-Port Digital Input Expansion Module 80
I2-EDI16 Specifications 80
Digital Input Expansion Module Library 81
eportIn 81
eportBlockIn 81
8-Port Relay Output Expansion Module 82
RS-EDOR8 Specifications 82
Relay Output Expansion Module Library 83
eRelay 83
eRelayBlock 83
Chapter 6 High-Speed Counter Module 84
High-Speed Counter Module 85
High-Speed Counter Module Library 86
countMode 86
count 87
countPrescaler 88
countReset 88
pwm 89
pwmOff 90

freqOut *91*
Using the PWM Output 92
Chapter 7 Communication Module **94**
Communication Module 95
Communication Module Library 97
openCom *97*
comPut *99*
comPrint *100*
comGet *101*
comGetInterval *102*
comFlush *103*
comGets *103*
comPuts *104*
comPower *104*
Chapter 8 Motion Control Module **106**
2-Axis Motion Control Module 107
Open-Loop System 108
2-Axis Motion Control Library 109
motorSetup *109*
motorMove *109*
setMotorPos *110*
getMotorPos *110*
motorStop *110*
motorStat *111*
Chapter 9 Analog Modules **112**
AD Input Module 113
RS-ADIN4, RS-HADIN4 Specifications 113
RS-SADIN6 Specifications 113
RS-ADIN4, RS-HADIN4 Analog Input Module 114
RS-SADIN6 6-Channel 12-bit Analog Input Module 115
AD Input Module Library 116
getAdc *116*
getHadc *116*
getSadc *117*
DA Voltage Output Module 119
RS-DAOUT2 Specifications 119
dacOut *120*
DA Current Output Module 121
RS-DAOUT2B Specifications 121
dacOut2 ..... *122*
Temperature Input Module 123
Temperature Input Module Library 124
getTemp *124*
Chapter 10 Ethernet Module **126**
Ethernet Module 127
LED Descriptions 127
Network Connectivity 127
TCP Client-Server Communication 128
Ethernet Module Library 129

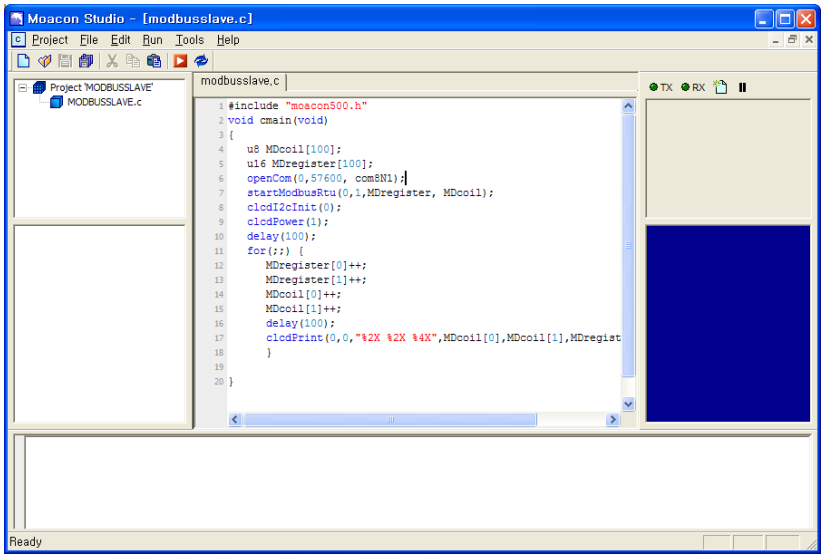
netBegin....129
socketOpen....129
socketClose....130
listen....130
connect....130
disConnect....130
netStatus....131
netSend....131
netPrint....131
netTxFree....132
netRecv....132
netRxLen....132
Sample Program....132
Chapter 11 Display Library....136
Display Devices....137
CLCD Library....138
clcdI2cInit....138
clcdUartInit....138
clcdCls....138
clcdCsr....138
clcdPrint....138
clcdLocate....139
clcdBlit....139
clcdPower....139
CSG Library....140
csgPrint....141
csgPrintDot....142
csgNput....143
csgXput....144
Chapter 12 Modbus RTU....146
About Modbus....147
Function Code 01/02: Read Coil/Input Status....149
Function Code 03/04: Read Holding/Input Registers....150
Function Code 05: Force Single Coil....151
Function Code 06: Preset Single Registers....152
Function Code 15: Force Multiple Coils....153
Function Code 16: Preset Multiple Registers....154
Modbus RTU Library....155
startModbusRtu....155
RTU_readCoils....155
RTU_readRegs....156
RTU_readInRegs....156
RTU_writeCoil....157
RTU_writeReg....157
RTU_writeCoils....157
getCrc....158
Chapter 14 Appendix....160
External Dimensions....161

Chapter 1 MOACON Overview

MOACON Studio

MOACON Studio is the integrated development environment software needed to develop for the MOACON. It can be downloaded from the Comfile Technology website at www.ComfileTech.com.

MOACON Studio features a C compiler, source editor, RS-232 communication, USB downloading and debugging, and more. The source editor features syntax highlighting, command completion, and context sensitive help making learning, developing, and testing MOACON software projects a truly productive and enjoyable experience.



By just clicking the "Run" icon ( ) MOACON Studio compiles and downloads the current MOACON project to the CPU module where it begins executing immediately.

Once downloaded, the MOACON can be disconnected from the PC and the MOACON will execute the compiled code as a standalone program. The program will be retained in the CPU module's flash memory even if the MOACON is powered off.

When powered back on, the MOACON will immediately begin executing the downloaded program. A new program can be downloaded from MOACON Studio at any time, replacing any existing program in the CPU module's flash memory.

CPU Module

The CPU module is the MOACON's core processing module.

The CPU module features the following:

- 32-bit ARM Processor (ARM CORTEX)
- Clock Speed: 72MHz
- Program Memory: 512KB Flash Memory
- Data Memory: 64KB SRAM
- Non-volatile Memory: 32KB F-RAM
- Built-in Real-Time Clock and Battery
- Built-in RS-232 Port
- LCD and 7-Segment Control Port
- 24V Power Input (Built -in Power Regulator)

Modules

The MOACON has several modules that can be purchased to support a variety of features.

DIO Modules (Digital Input/Output Modules)

Model Name	Description	Voltage/Current Rating
CF-DOSI8	8-pin DC Sink Output Module	DC 3.3V ~ 27V 1A
CF-DOSO8	8-pin DC Source Output Module	DC 12V ~ 24V 1A
CF-DORL8	8-pin Relay Output Module	DC 6 ~ 27V 4A AC 6 ~ 240V 4A
CF-DIDC8	8-pin DC Input Module	DC 12V ~ 24V
I2-EDI16	16-pin Digital Input Expansion Module	DC 12V ~ 24V
RS-EDOR8	8-pin Digital Output Expansion Module	DC 6 ~ 27V 4A AC 6 ~ 240V 4A

Analog Modules

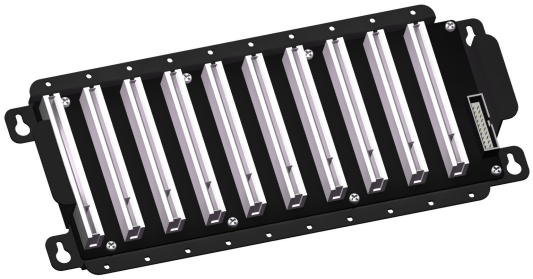
Model Name	Module Type	Description	Specifications
RS-ADIN4	AD Input Module	4-Channel 13.3 bit AD Conversion	0~10V, 1~5V, 4~20mA
RS-HADIN4	High Resolution AD Input Module	4-Channel 16.6 bit AD Converter	0~10V, 1~5V, 4~20mA
RS-THRT4	Temperature Input Module	4-Channel PT100Ω Temperature Sensor	-100 ~ 500 °C
RS-DAOUT2	2-Channel DA Voltage Output	2-Channel 16-bit DA Converter	0~10V, 0~5V
RS-DAOUT2B	2-Channel DA Current Output	2-Channel 16-bit DA Converter	4~20mA, 0~20mA

Specialized Modules

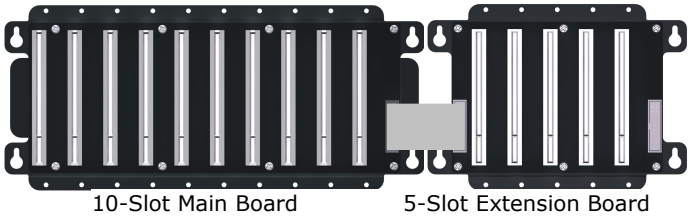
Model Name	Module Type	Description
DP-COMM2	Serial Communication Module	2 RS-232 Ports 1 RS-232 Port and 1 RS-485 Port
DP-HCNT	High Speed Counter	2-Channel High-Speed Counter Input OR 2-Channel Encoder Input AND 8-Channel PWM Output
DP-ETHER	Ethernet Module	Ethernet Port
RS-MOT2	2-Axis Motion Control Module	2-Axis Stepper Motor Control

Module Board

The main module board comes in a 10-slot configuration.

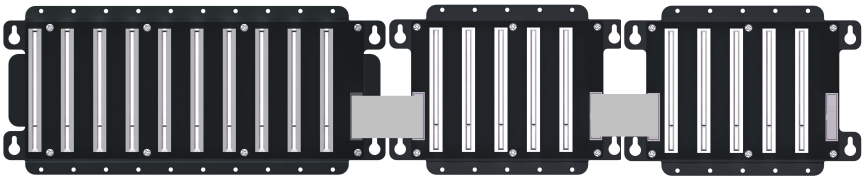


If 10 slots are insufficient, a 5-slot extension board can be connected to the 10-slot board to increase the capacity for additional modules.



10-Slot Main Board 5-Slot Extension Board

If 15 slots are still not enough, an additional 5-slot Extension board can be connected increasing the capacity to a maximum of 20 modules.



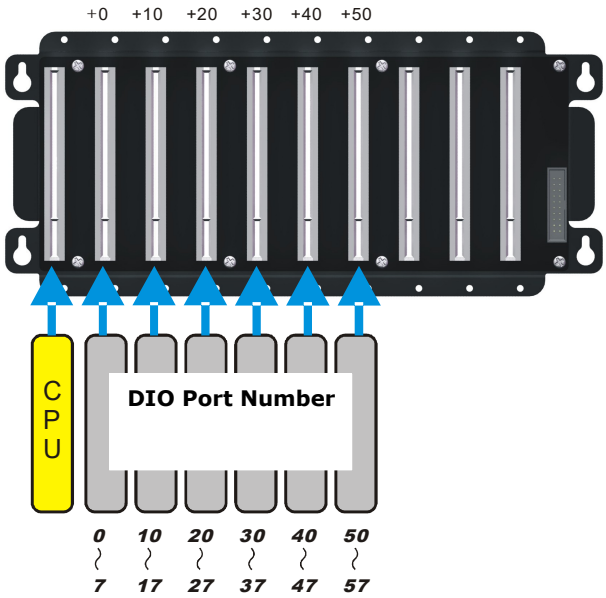
The module board array must be terminated, so if you connected additional module boards, be sure to terminate the last board in the array. A terminator is included with each board.

Installing General DIO Modules

WARNING: Do not plug or unplug modules while the power is on.

Module Name	Module Type	Maximum Number of Concurrent Modules
CF-DOSI8	8-pin DC Sink Output	6
CF-DOSO8	8-pin DC Source Output	6
CF-DORL8	8-pin RELAY Output	6
CF-DIDC8	8-pin DC Input	6

The CPU module must be mounted on the far left of the 10-slot main board in the position labeled "CPU". General Digital I/O (DIO) modules can be installed in the 6 slots directly to the right of the CPU module in the slots labeled "DIO". The slot in which the DIO module is installed determines its I/O port number.



When a general DIO module is installed in position "+0" its ports will be assigned numbers 0 through 7. When installed in position "+30" its ports will be assigned numbers 30 through 37.

The following image illustrates a CPU module installed with 6 general DIO modules.

[One CPU module installed with 6 DIO modules]

More than one of the same type of general DIO module can be installed concurrently as shown below.

[One CPU module installed with 3 identical output modules]

Installing Expansion DIO Modules

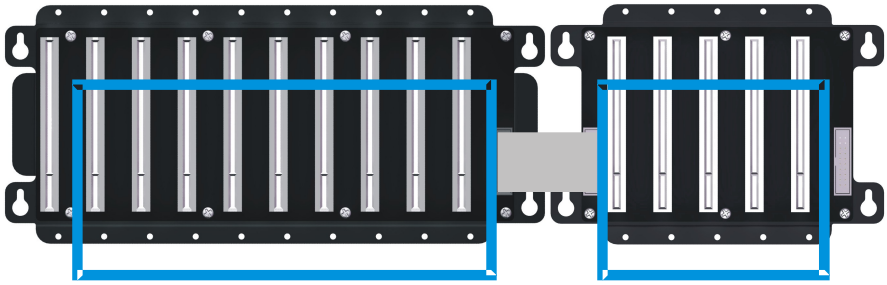
WARNING: Do not plug or unplug modules while the power is on.

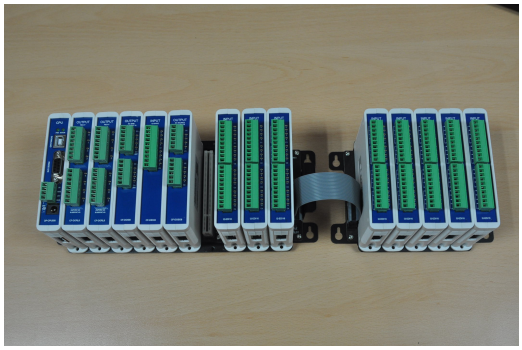
Model Name	Model Type	Maximum Number of Concurrent Modules
I2-EDI16	16-pin Expansion Digital Input Module	8
RS-EDOR8	8-pin Expansion Relay Output Module	10

The MOACON provides a total of 48 digital I/O ports. If more than 48 are needed, these expansion DIO modules can be used to increase the number of digital I/O ports.

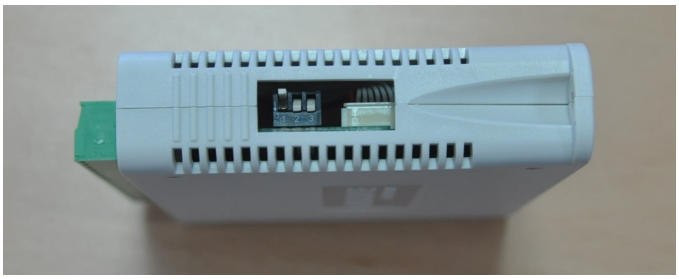
Up to 8 I2-EDI16 modules can be installed to expand DC input to a maximum of 128 pins. Up to 10 RS-EDOR8 modules can be installed to expand relay output to a maximum of 80 pins.

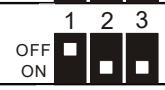
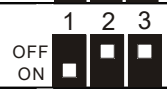
The expansion DIO modules can be installed in any slot on either the 10-slot main board or the 5-slot expansion board, except the CPU slot.



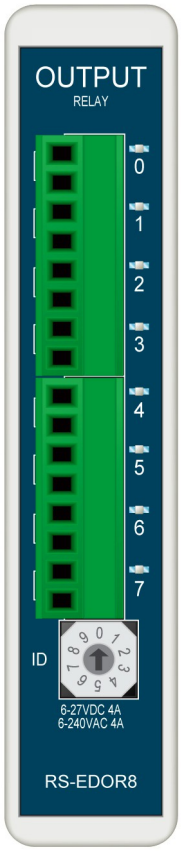


The dipswitch on the side of the I2-EDI16 digital input expansion module is used to assign the module to a port block



Dipswitch Configuration	Port Block Number	Port Number (Hexadecimal)
	0	00 - 0F
	1	10 - 1F
	2	20 - 2F
	3	30 - 3F
	4	40 - 4F
	5	50 - 5F
	6	60 - 6F
	7	70 - 7F

The rotary switch on the face of the RS-EDOR8 relay output expansion module is used to assign the module to a port block.



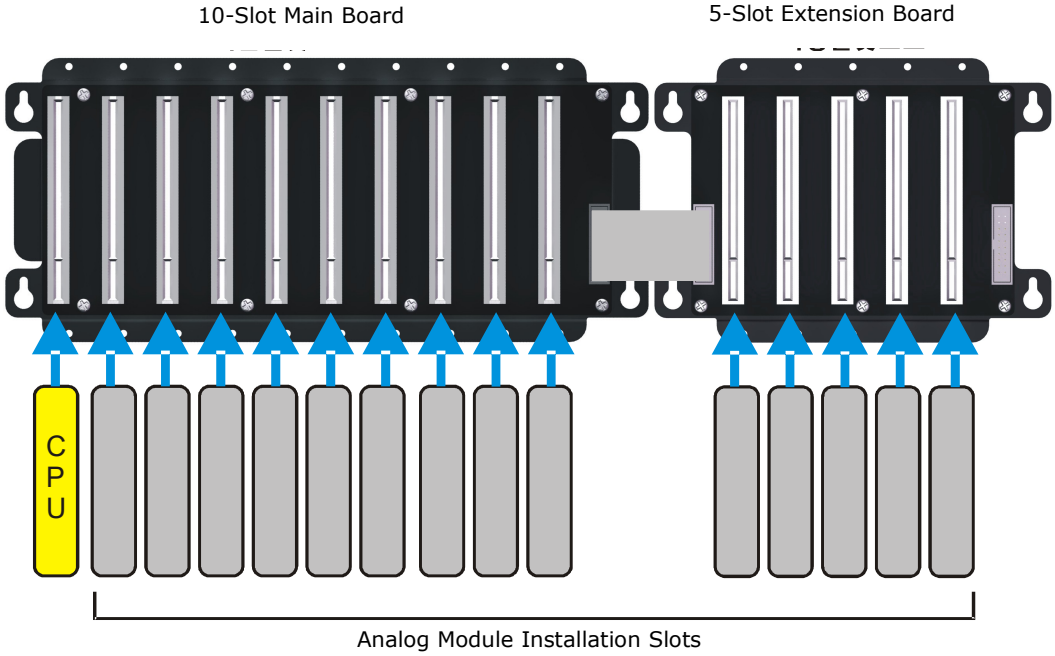
ID (Port Block)	Output Ports
0	0 - 7
1	10 - 17
2	20 - 27
3	30 - 37
4	40 - 47
5	50 - 57
6	60 - 67
7	70 - 77
8	80 - 87
9	90 - 97

Installing Analog Modules

WARNING: Do not plug or unplug modules while the power is on.

Module Name	Module Type	Maximum Number of Concurrent Modules
RS-ADIN4	4-Channel AD Input	10
RS-HADIN4	4-Channel High-Resolution AD Input	10
RS-THRT4	4-Channel Temperature Input	10
RS-DAOUT2	2-Channel DA Voltage Output	10
RS-DAOUT2B	2-Channel DA Current Output	10

Analog modules can be installed in any slot except the CPU slot.



If the 10-slot main board does not have enough vacant slots, the analog modules can be installed in any of the 5-slot expansion board slots.

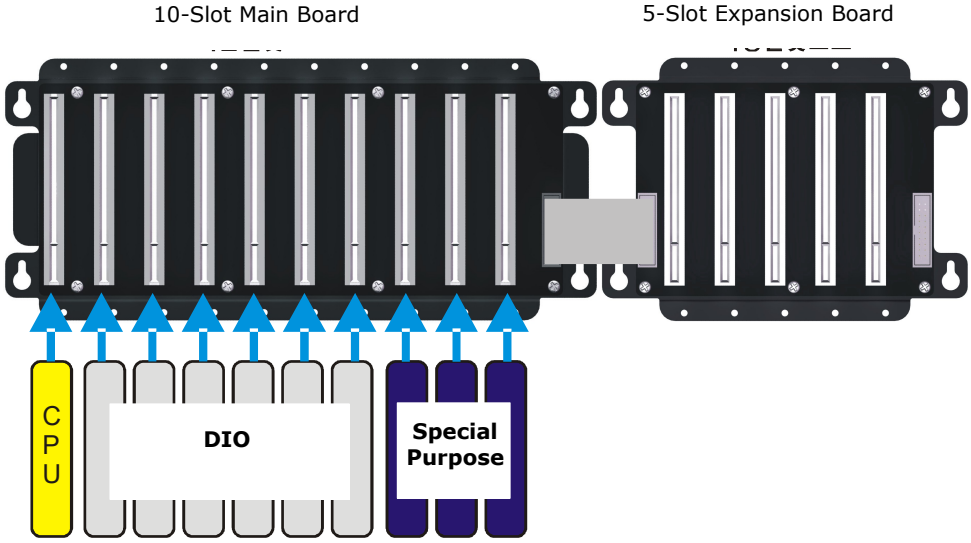
A maximum of 10 analog modules of the same type can be installed concurrently. Each module must be given a different ID number using the rotary switch on the module's face.

Installing Special Purpose Modules

WARNING: Do not plug or unplug modules while the power is on.

Model Name	Model Type	Maximum Number of Concurrent Modules
DP-COMM2	Communication Module	1
DP-HCNT	High-Speed Counter Module	1
DP-ETHER	Ethernet Module	1

Only one of each type of special purpose module can be installed at a time. For example, you can install one communication module, one high-speed counter module, and one Ethernet module concurrently, but you can't install 2 or more communication modules, high-speed counter modules, or Ethernet modules concurrently.



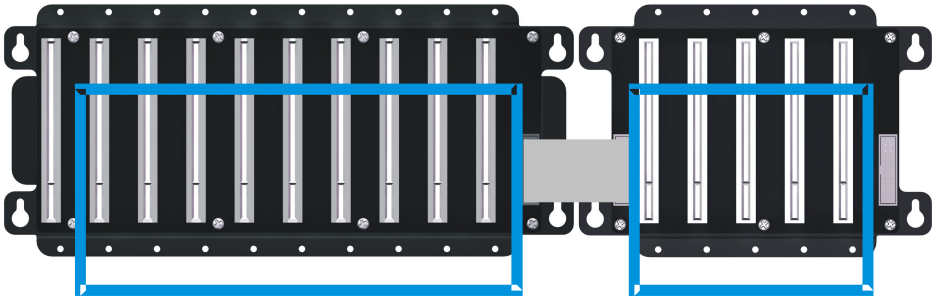
As shown in the image above, special purpose modules can be installed in any vacant slot on the 10-slot main board. **Special Purpose Modules cannot be installed in the expansion boards.**

Installing Motion Control Modules

WARNING: Do not plug or unplug modules while the power is on.

Module Name	Module Type	Maximum Number of Concurrent Modules
RS-MOT2	2-Axis Motion Control Module	10

Analog modules can be installed in any slot except the CPU slot. Up to 10 Motion Control Modules can be installed concurrently.



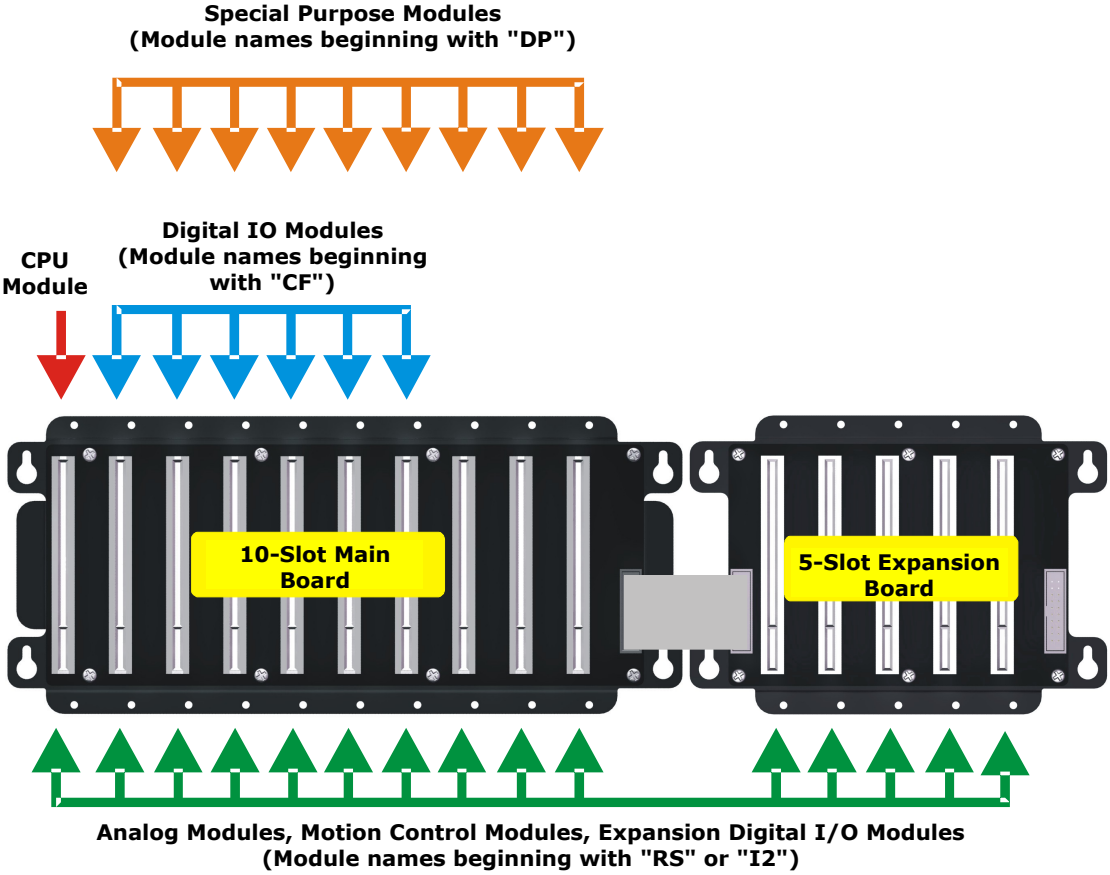
If the 10-slot main board does not have enough vacant slots, the motion control modules can be installed in any of the 5-slot expansion board slots.

Up to 10 Motion Control Modules can be installed concurrently, so a maximum of 20 stepper motors can be controlled simultaneously.

*Module names starting with "RS" imply that the module is connected internally to an RS-485 network.

Module Installation Summary

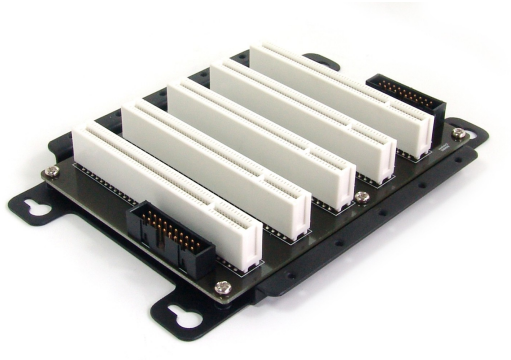
The following image summarizes the installation of each type of module.


Special Purpose Modules
(Module names beginning with "DP")
CPU Module
Digital IO Modules
(Module names beginning with "CF")
10-Slot Main Board
5-Slot Expansion Board
Analog Modules, Motion Control Modules, Expansion Digital I/O Modules
(Module names beginning with "RS" or "I2")

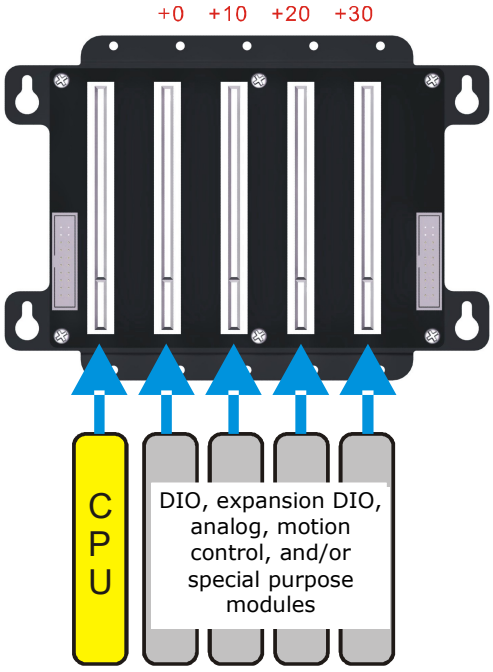
The appropriate installation slot can be determined just by the mode name. The special purpose modules whose names begin with "DP" (e.g. DP-COMM2 communication module, DP-HCNT high-speed counter module, or the DP-ETHER Ethernet module) can be installed in any of the main board's slots except the CPU slot.

Small System Configuration

If you only require five modules or less, the 5-slot extension board can be used independently as a main board. This is referred to as the "Small System Configuration".



With the CPU module installed in the slot labeled "CPU", the remaining 4 slots can be used to host DIO modules, expansion DIO modules, analog modules, motion control modules, and/or special purpose modules.



Note that when using the Small System Configuration, the general DIO modules can be installed in any of the board's slots labeled "DIO". Just like the 10-slot board, the slot in which the general DIO module is installed determines its port number.

When the 5-slot board is used as an expansion board, however, the general DIO modules cannot be installed in the 5-slot board. When the 5-slot board is used as an expansion board, the expansion DIO modules must be used instead.

The following image shows the 5-slot board being used independently as a main board.

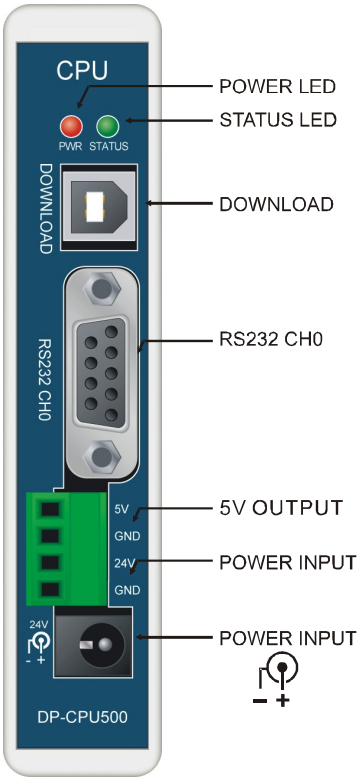
[CPU module, 3 DIO modules, and one communication module]

[CPU module, a high-speed counter module, and one communication module]

Chapter 2
Setup

MOACON CPU Module

The MOACON CPU module (DP-CPU500) comes with an external power supply (5V 2A Output, 10W power supply). This power supply will power all the modules in the system when connected to the CPU module, so power supplies are not included with any other IO module.



POWER LED: Lit when power supplied.
STATUS LED: Set using `statusLed` command.

DOWNLOAD: Connect to PC. Use for program downloading and debugging.

RS232 CH0: Built-in RS-232 Channel 0 for interfacing to RS-232 capable devices.

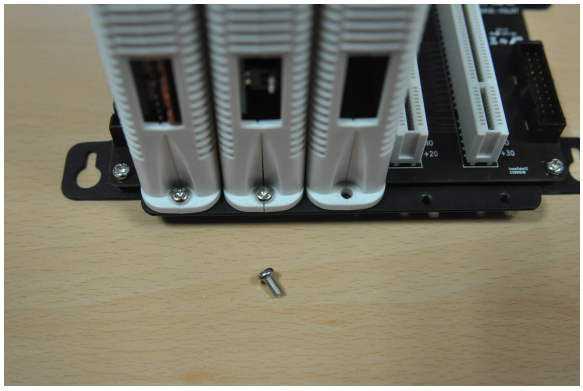
5V OUTPUT: Internally generated 5V output terminal

POWER INPUT: 24V Power Input. Use either the barrel jack or the header, but not both.

DP-CPU500 Specifications	
Input Voltage	24VDC
Input Voltage Range	18 – 28VDC
Approx. RTC Battery Life	10 years
Operating Temperature	0 ~ 55 °C
Storage Temperature	-20 ~ 70 °C

Installation

All modules should be secured to the slot board with screws. Vibration and shock can result in poor electrical contact and other problems. Failure to secure the modules with screws may result in malfunction and/or damage.

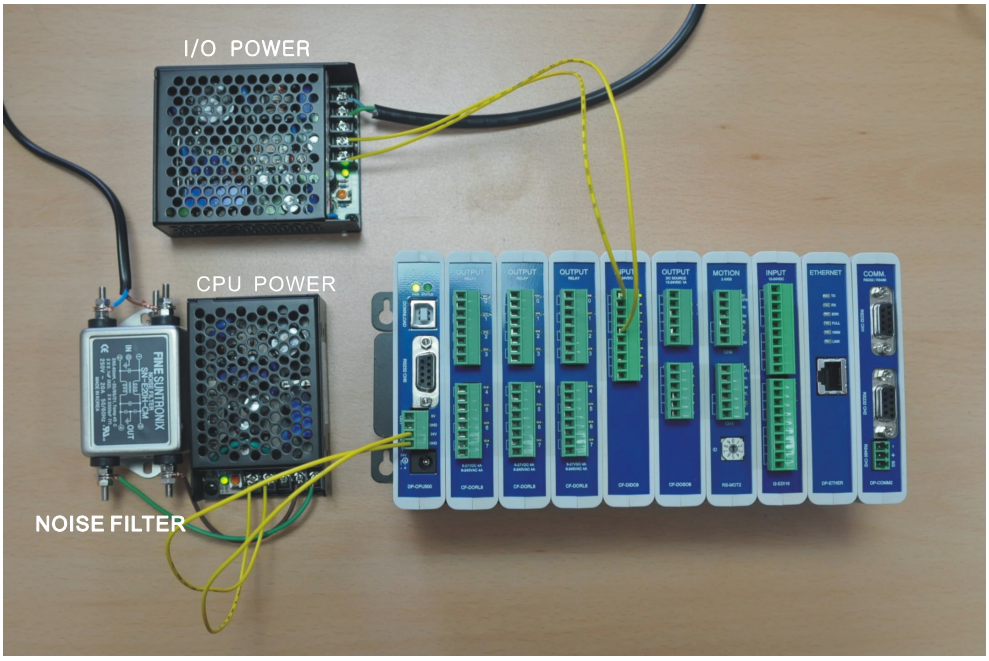


Please avoid operating the MOACON in the following conditions:

- Where ambient temperature exceeds 55 °C
- Where relative humidity is not within 30 ~ 60%
- Where the MOACON could be subject to excessive vibration or shock
- In direct sunlight
- Near a heat source
- Near a transformer of other high-voltage source.

Supplying Power

It is recommended to separate the power to the CPU module and the power that drives the I/O circuits. Two 24V power sources can be used as shown below. One powers the CPU, while the other drives the I/O circuit.

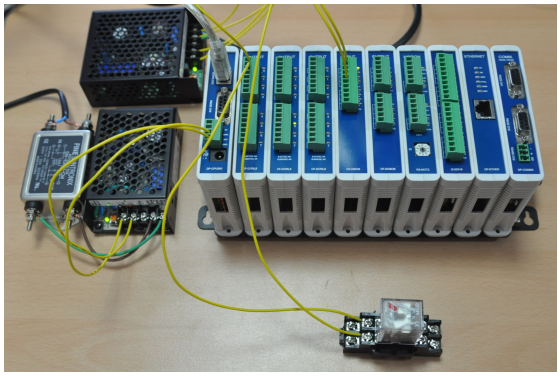


Separating the CPU's power and I/O power will result in a more stable operation. The system will be less susceptible to noise, and if a short occurs in the I/O circuit, the CPU, and therefore the rest system, will not be negatively affected.

When powering the CPU from an A/C power source, a noise filter is also recommended.

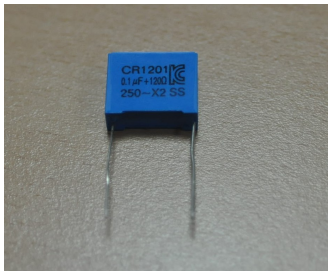
Surge Killer

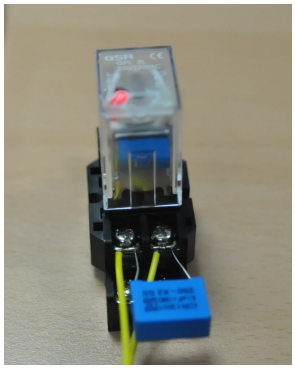
When using the Relay Output Module with a large capacity product, it is recommended to add a relay that can bear a large load.



When such a relay is added, turning the relay on and off can cause a large voltage surge to occur due to the coil's inductance. This voltage surge should be removed to ensure the stability of the entire system, and the longevity of the relay's life.

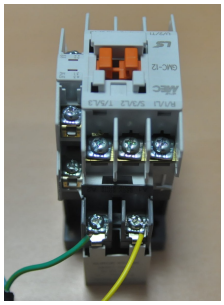
A spark killer or surge killer can be used to guard against this anomaly. As shown in the pictures below, the surge killer should be connected in parallel to the source of the surge.



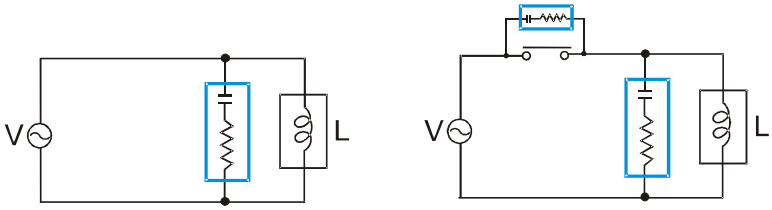


Power Relay Wiring

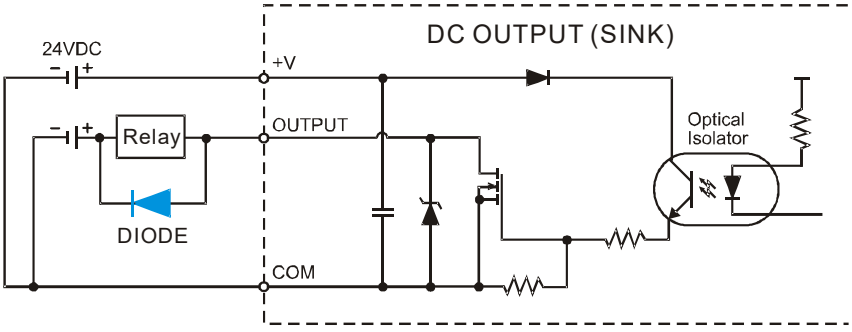
If using a magnetic contact, attach a surge killer as shown in the pictures below



The following schematic illustrates how to attach the surge killer to an AC circuit.



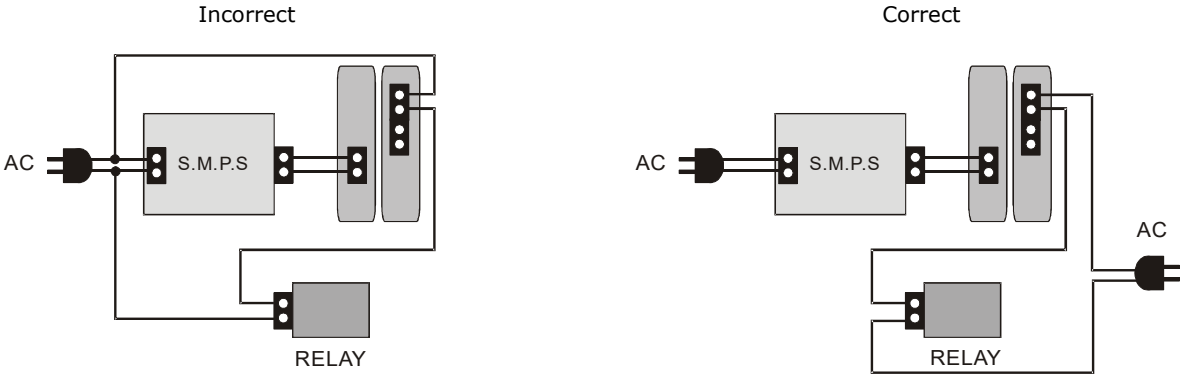
In a DC circuit, a diode can be used. A typical diode used for this purpose is the 1N4148.



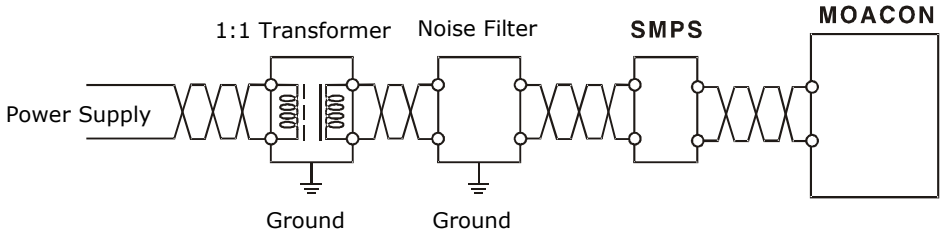
This method is less expensive and more effective in eliminating noise in the circuit. When using this method, be sure not to switch the relay on or off at a frequency greater than 2Hz.

Relay Power Wiring

Do not wire the power for an external relay to the same circuit as the controller's SMPS (Switched Mode Power Supply) as noise from the relay switching on and off can negatively influence the operation of the power supply.



To achieve a more reliable operation, connect a shield transformer (1:1) before the controller's power supply.



Power wiring is very important. If power supply noise cannot be controlled, the system will not be stable. Ensure the following to keep noise at a minimum.

1. Power wires should be thick and twisted together to reduce noise.
2. Isolation transformer wires should also be twisted together to reduce noise and connected in close proximity to the controller.
3. Be sure the SMPS is properly grounded.
4. Do not put AC and DC signals in close proximity to one another.
5. Separate signal wires and power wires by at least 20cm.
6. Separate input and output signal wires.
7. Keep magnetic switches, potential relays, and power relays away from the controller.

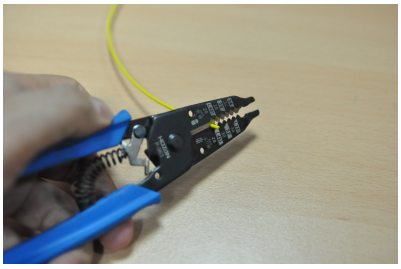
Also, be aware of the capabilities of your power supply. Overloading your power supply may result in overheating and ultimate system failure.

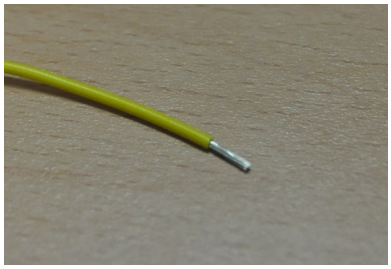
Keeping your control panel properly ventilated, especially in hot weather, will help reduce the risk of overheating.

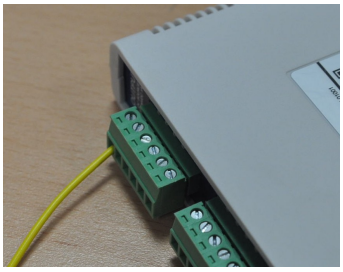
Wiring

PVC coated wire with a thickness of about **AWG20** is suitable for most I/O signals. (**AWG20** wire is available at www.ComfileTech.com).

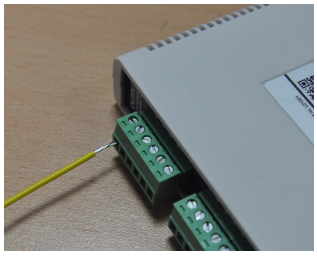
Strip the wire with a wire-stripping tool, insert into the module's terminal block, and tighten with a screwdriver. Soldering the ends of the wires is not recommended.







Correct



Incorrect

Be sure no bare wire is exposed outside of the terminal block as shown above.

For power signals, using a wire thickness between **AWG16 ~ AWG12** is recommended.

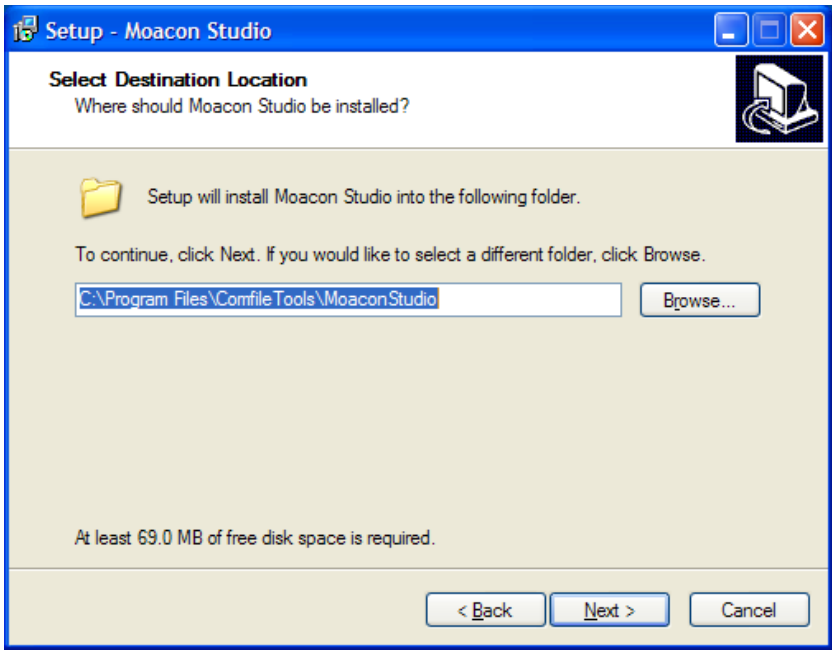
Software Installation

This section will explain how to install MOACON Studio and the MOACON's USB driver. These instructions will describe the procedure for Windows XP, but the procedure is similar for Windows Vista and Windows 7.

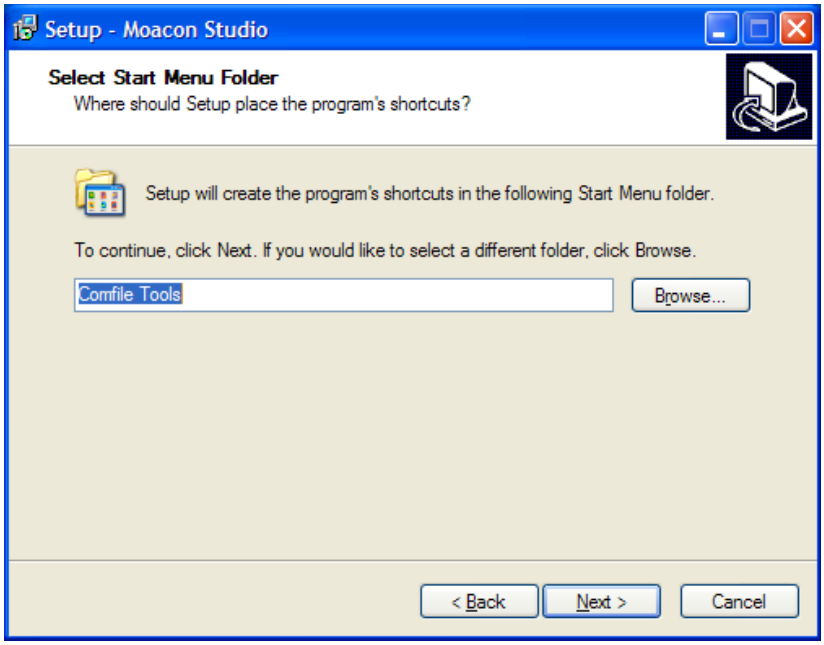
1. Download MOACON Studio setup program from the Comfile Technology website at www.ComfileTech.com and execute in on a PC.

Setup - Moacon Studio
Welcome to the Moacon Studio Setup Wizard
This will install Moacon Studio on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue, or Cancel to exit Setup.
Next >
Cancel

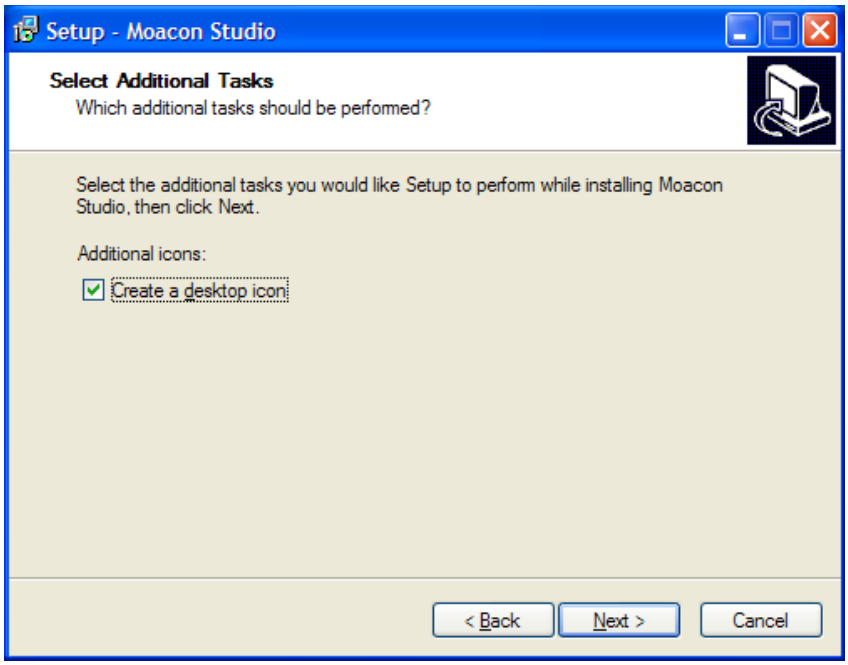
2. When the window above appears, click the "Next" button.


Setup - Moacon Studio
Select Destination Location
Where should Moacon Studio be installed?
Setup will install Moacon Studio into the following folder.
To continue, click Next. If you would like to select a different folder, click Browse.
C:\Program Files\ComfileTools\MoaconStudio
Browse...
At least 69.0 MB of free disk space is required.
< Back
Next >
Cancel

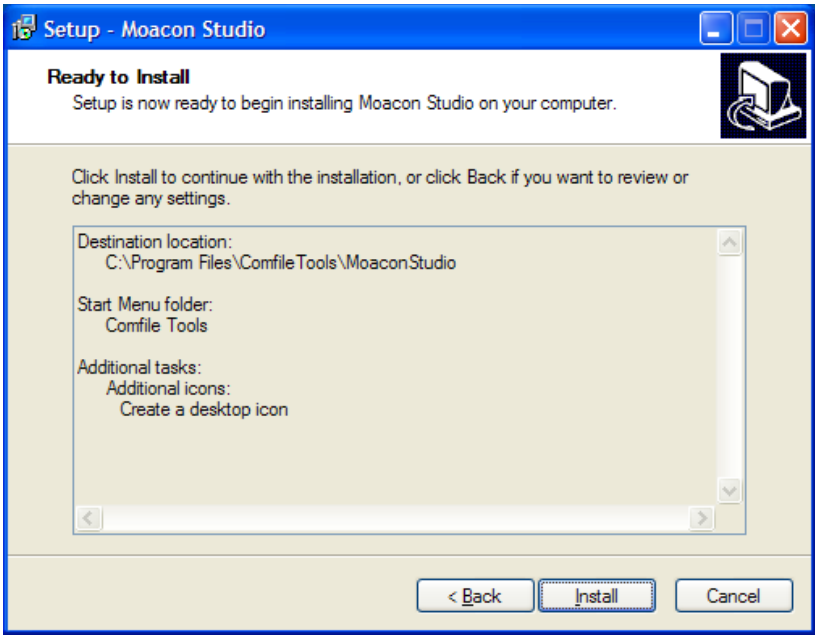
3. When the window above appears, accept the default or change the installation folder to your liking and click the "Next" button.


Setup - Moacon Studio
Select Start Menu Folder
Where should Setup place the program's shortcuts?
Setup will create the program's shortcuts in the following Start Menu folder.
To continue, click Next. If you would like to select a different folder, click Browse.
Comfile Tools
Browse...
< Back
Next >
Cancel

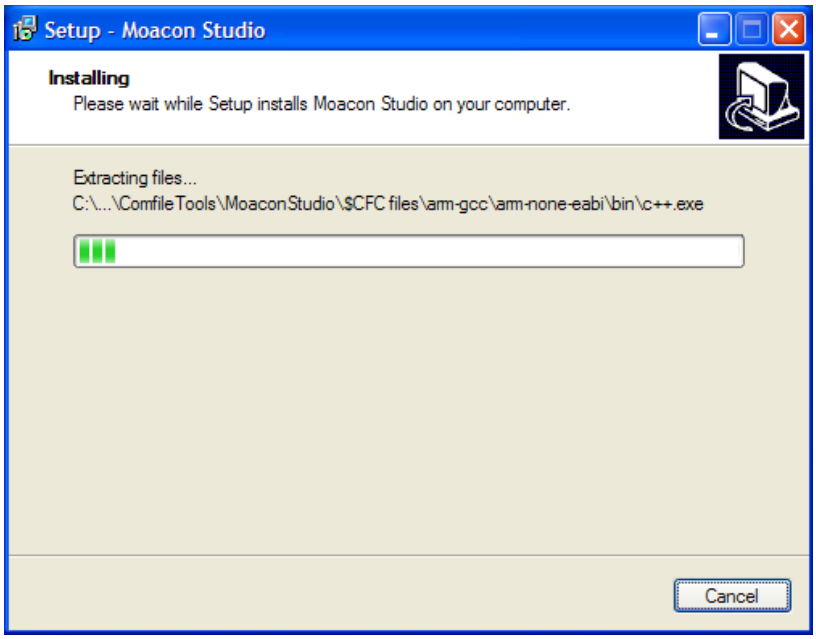
4. When the window above appears, accept the default or change the start menu folder and click the "Next" button.


Setup - Moacon Studio
Select Additional Tasks
Which additional tasks should be performed?
Select the additional tasks you would like Setup to perform while installing Moacon Studio, then click Next.
Additional icons:
Create a desktop icon
< Back
Next >
Cancel

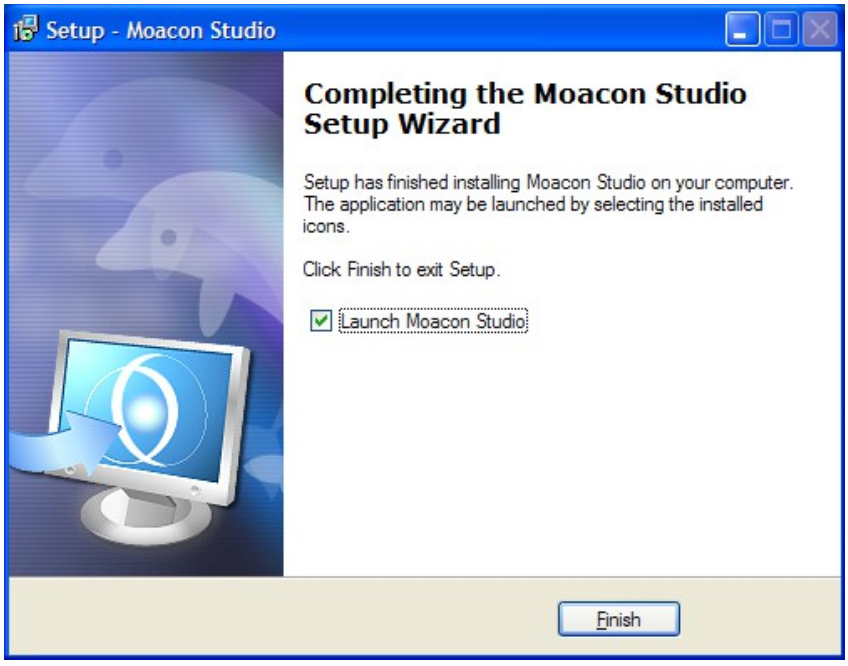
5. Check the "Create a desktop icon" checkbox to indicate whether or not you want a desktop icon and click the "Next" button.


Setup - Moacon Studio
Ready to Install
Setup is now ready to begin installing Moacon Studio on your computer.
Click Install to continue with the installation, or click Back if you want to review or change any settings.
Destination location:
C:\Program Files\ComfileTools\MoaconStudio
Start Menu folder:
Comfile Tools
Additional tasks:
Additional icons:
Create a desktop icon
< Back
Install
Cancel

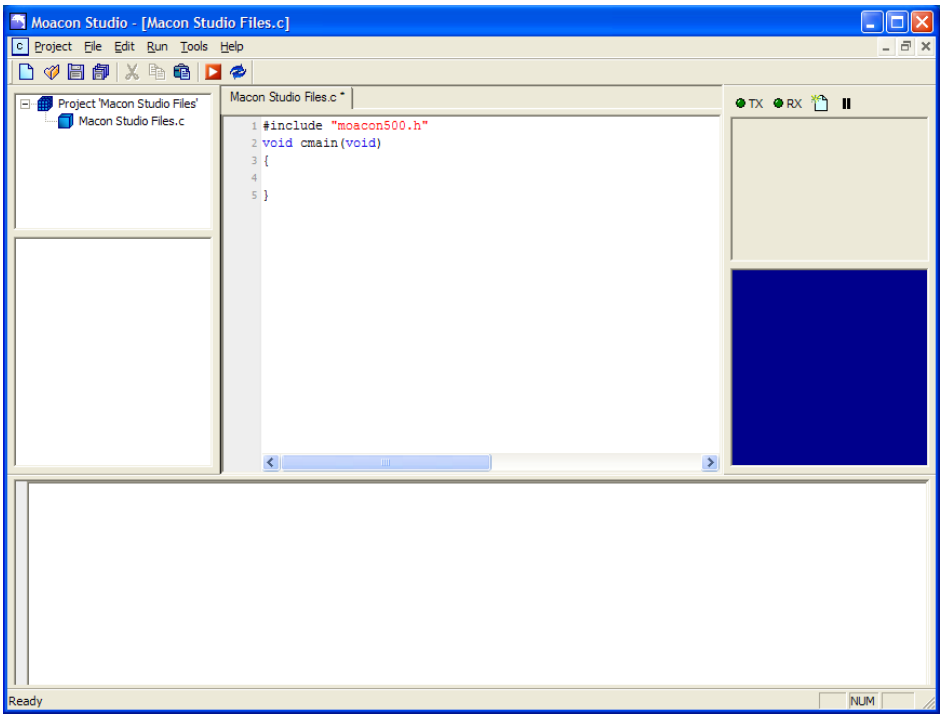
6. Review the installation summary. If you need changes, click the "Back" button. If everything is to your liking, click the "Install" button.



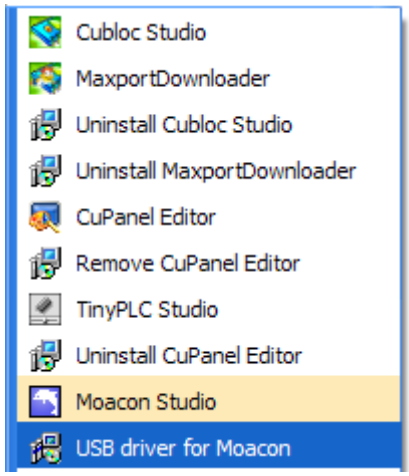
7. MOACON Studio will begin installing. Wait for it to finish.


Setup - Moacon Studio
Completing the Moacon Studio Setup Wizard
Setup has finished installing Moacon Studio on your computer. The application may be launched by selecting the installed icons.
Click Finish to exit Setup.
Launch Moacon Studio
Finish

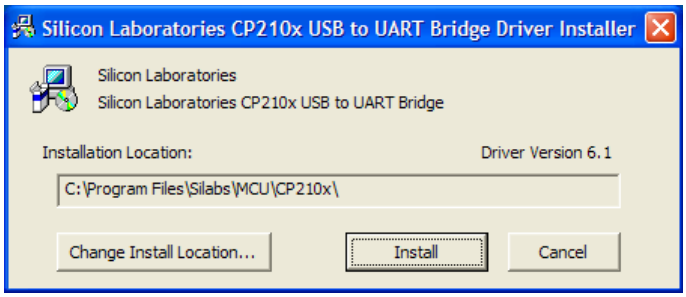
8. When the installation is finished, decide if you want to run MOACON Studio immediately by checking the "Launch Moacon Studio" checkbox, and click the "Finish" button.



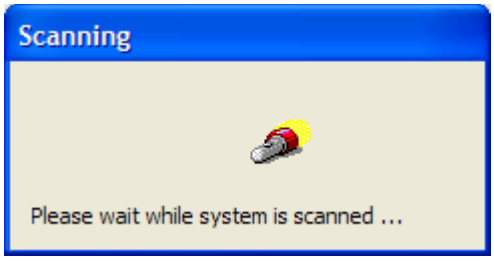
9. When MOACON Studio is run, the main window will appear.



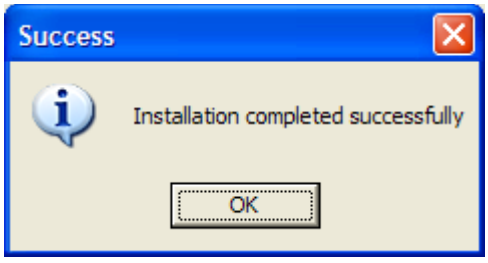
10. Before MOACON Studio can be used with the MOACON, the USB driver must be installed. Go to "Start" → "Programs" → "Comfile Tools" → "USB driver for Moacon" to begin the installation.



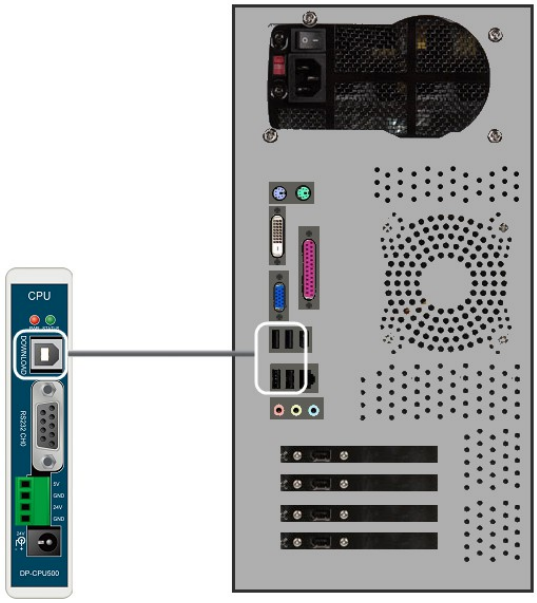
11. When the window above appears, accept the defaults or change the installation location and click the "Install" button.



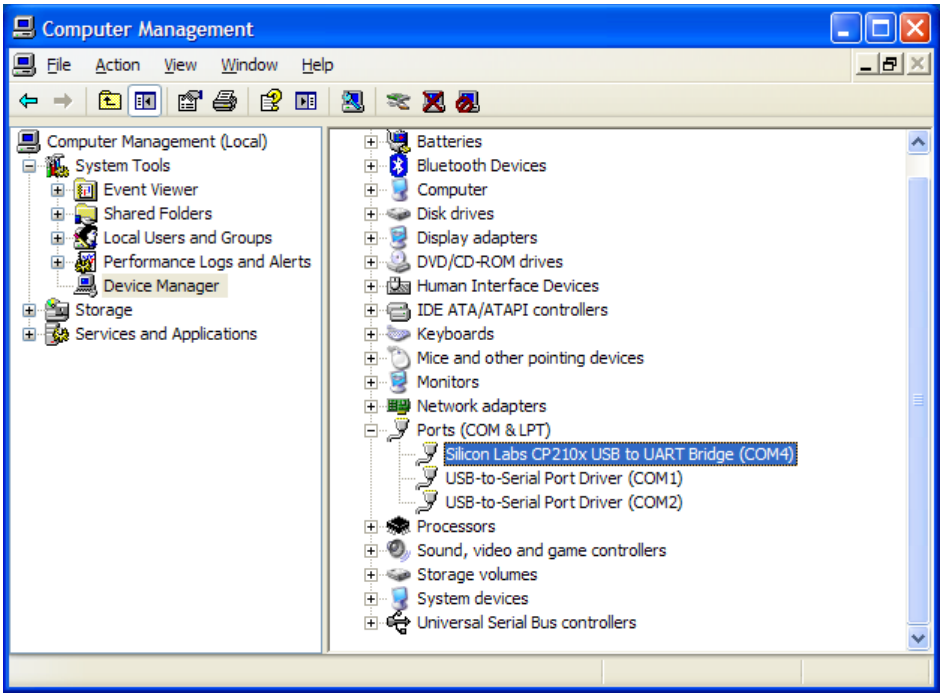
12. The installation program will scan your computer for existing drivers.



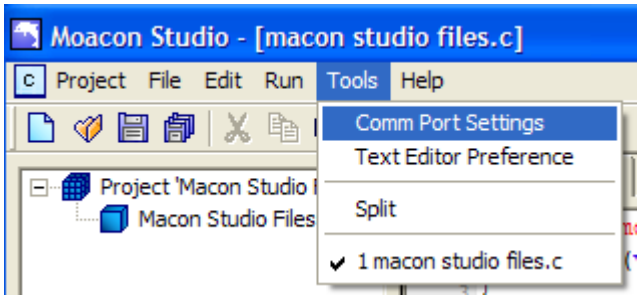
13. When the installation is complete the window above will appear. Click the "OK" button to finish.



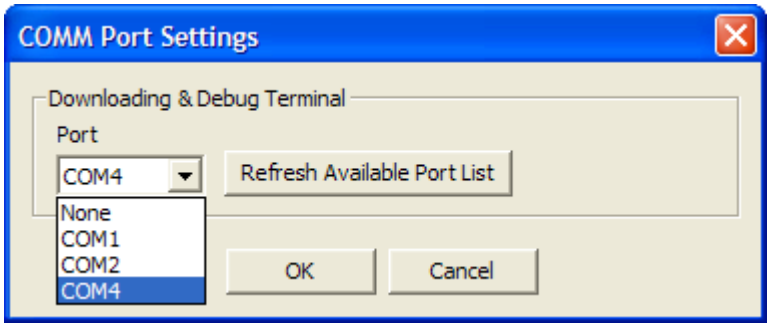
14. Once the installation is finished, power on the MOACON, and connect PC to the MOACON's "Download" port with a USB cable.



15. In the PC's Device Manager, you'll see that a COM port was created (Silicon Labs CP210x USB to UART Bridge). In the image above the MOACON is on COM4, but every PC will be different.



16. Open MOACON Studio and select "Tools" → "Comm Port Settings" from the menu.



17. Select the COM port on which the MOACON is connected. This should be the port shown in step 15 (COM4).

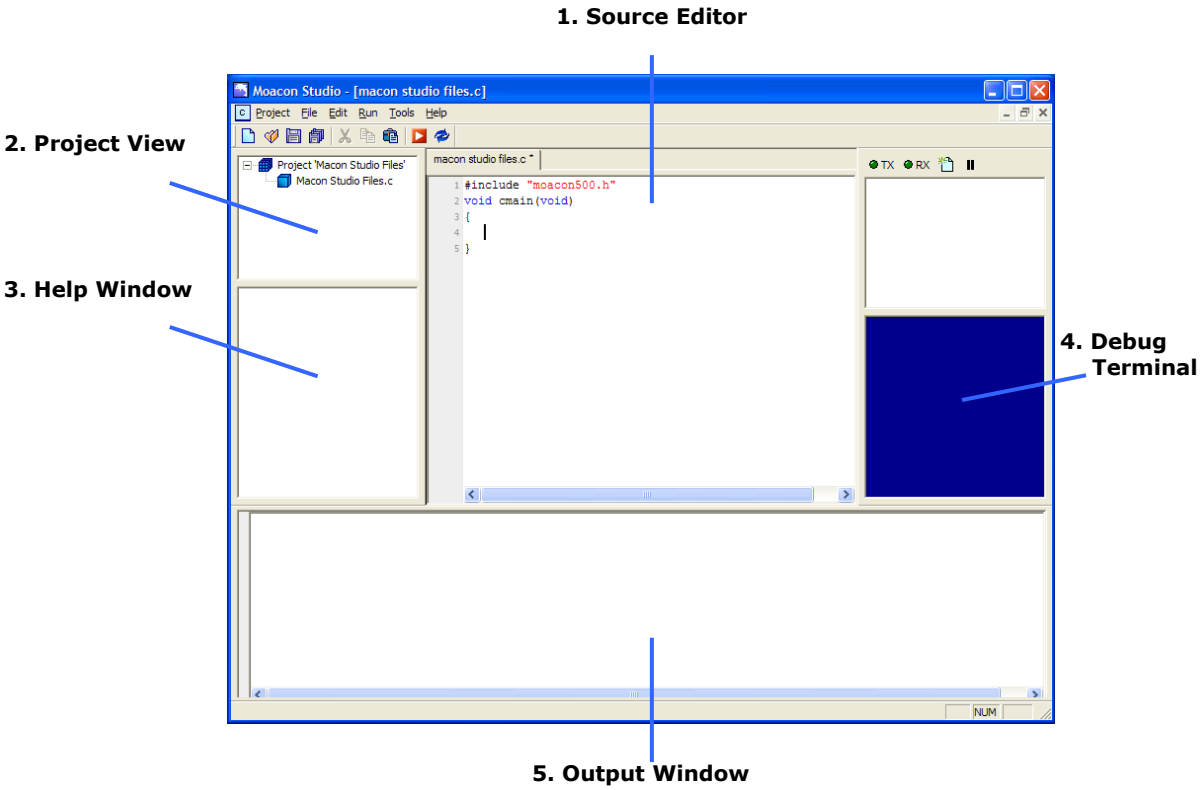
MOACON projects can now be created and downloaded to the MOACON using MOACON Studio.

Chapter 3 Programming the MOACON

The MOACON is programmed using the ANSI-C programming language. C is an extremely common programming language that has been around for more than 40 years and there are many great C programming resources available. It would be futile and unproductive to try and reproduce that material here, so this manual will only discuss the aspects of C programming that are applicable to the MOACON. Readers are encouraged to obtain additional material on programming in C to supplement this manual.

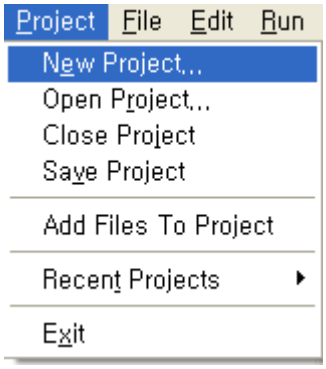
MOACON Studio

MOACON Studio is the integrated software development environment used to program the MOACON. The image below describes the main window.

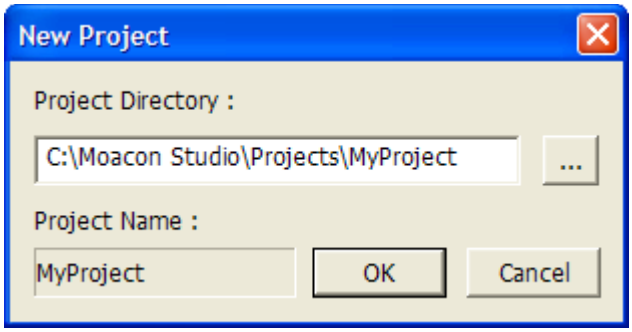


1. Source Editor – Text editor for source code.
2. Project View – Displays a list of all files in the current project.
3. Help Window – Shows command syntax and other documentation as you type in the source editor.
4. Debug Terminal – Output window for debugging messages.
5. Output Window – Shows compiler messages, download messages, and more.

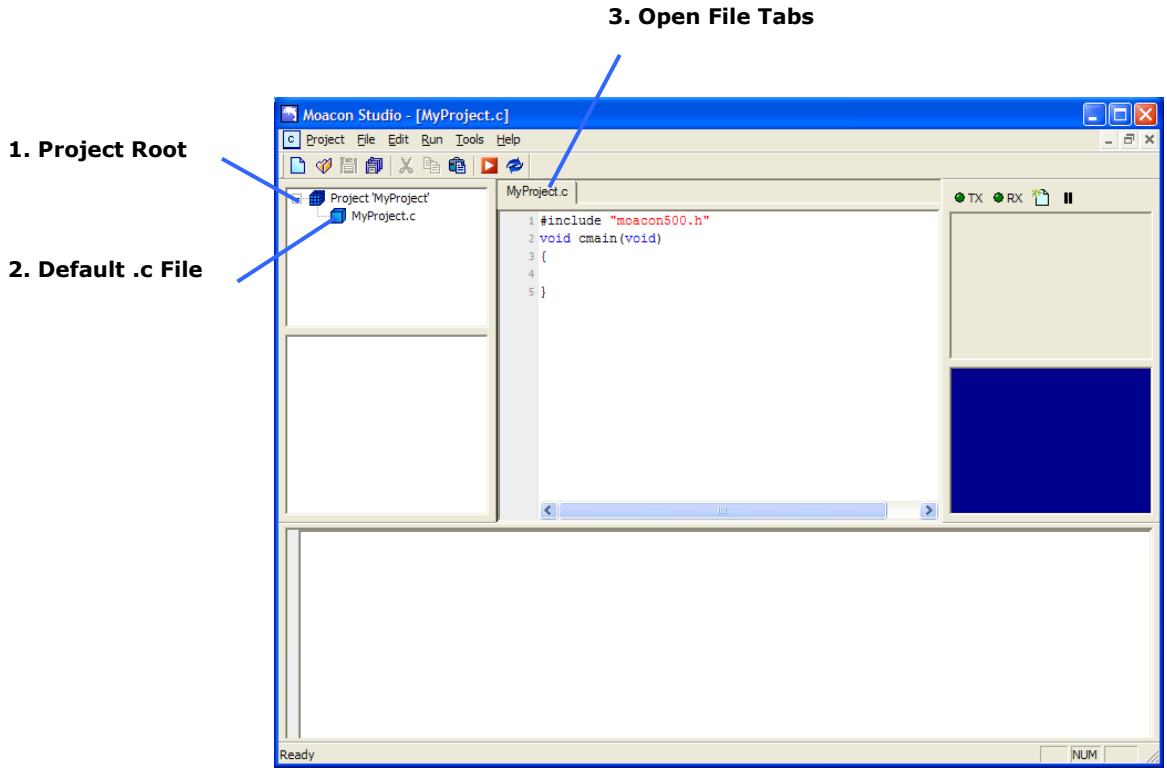
Creating a Project



To create a project in MOACON Studio, choose "Project" → "New Project…" from the main menu.



From the "New Project" dialog that appears, create or browse to an empty folder. The folder's name will become the project's name. When the project is created a [ProjectName].csp file will be created in this folder; this is the MOACON Studio project file. In the example above, a file named MyProject.csp will be created in the folder "C:\Moacon Studio\Projects\MyProject".



After creating a new project, the project will open in MOACON Studio and create a default [ProjectName].c file. In the example above, for project "MyProject" a default MyProject.c file was created.

1. Project Root – The root of the project. Source files will appear as children of this root.
2. Default .c File – The default source file. New source files can be created and added to the project. The source files do not have to reside in the project folder.
3. Open File Tabs – Any file open for editing will appear as a tab in the Source Editor Window.

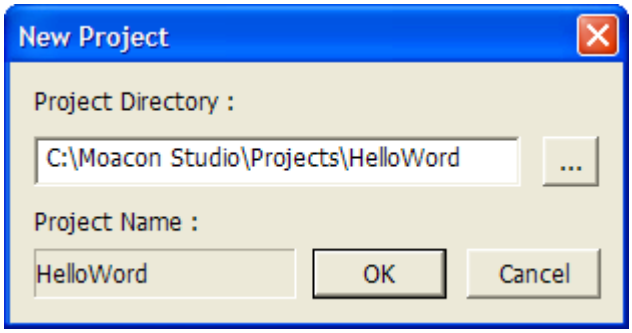
```
#include "moacon500.h"    //Device Declaration
void cmain(void)          //Program's Entry Point
{

}
```

The `#include "moacon500.h"` statement is a device declaration statement used to include code that is specific to the model of the CPU module – in this case the DP-CPU500. It should be included at the top of the main source file.

`cmain` is the program's entry point (i.e. the first function the program calls when it is executed). Note that in most C programs, the program's entry point is usually called `main`, but for the MOACON, it is `cmain`.

Compiling and Executing a Project

In this section we will create a very simple MOACON project, download it to the MOACON, and execute it. The famous "Hello World" program will be used to illustrate the procedure.

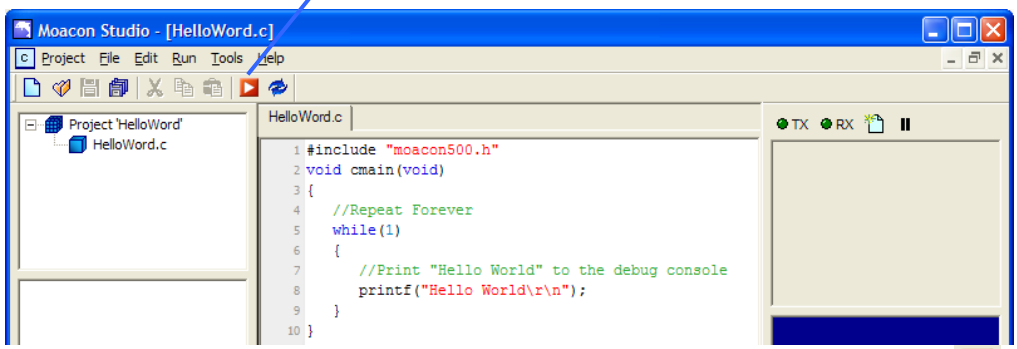


1. Create a new project called "HelloWorld".

```
#include "moacon500.h"
void cmain(void)
{
    //Repeat Forever
    while(1)
    {
        //Print "Hello World" to the debug console
        printf("Hello World\r\n");
    }
}
```

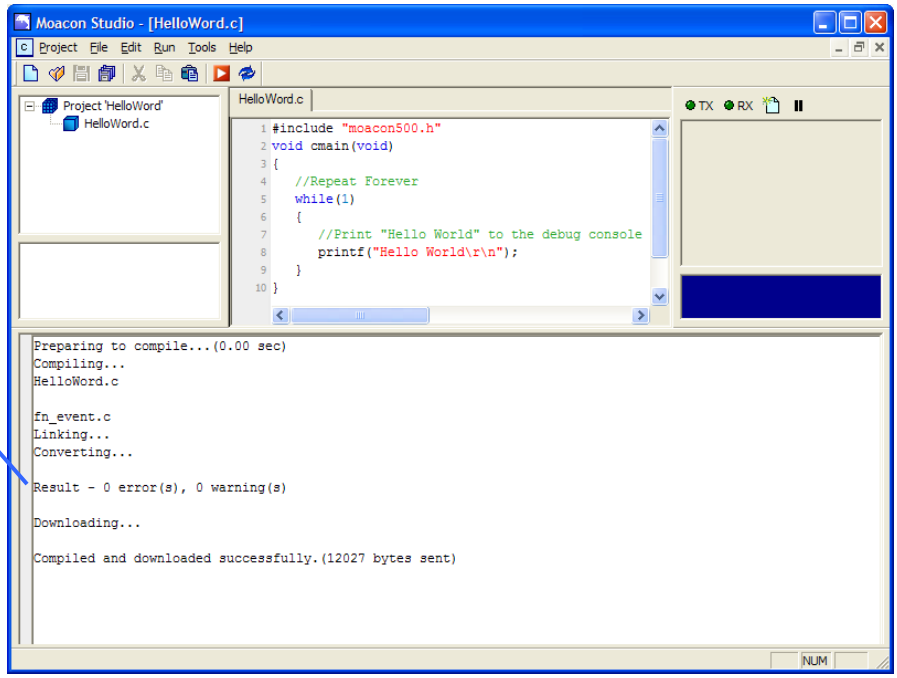
2. Enter the code above in the HelloWorld.c source file. The `while(1)` code block will execute forever without exiting. The `printf` statement will print "Hello World" to the Debug Terminal. The carriage return (`\r`) and new line (`\n`) will ensure each "Hello Word" gets printed on a new line.

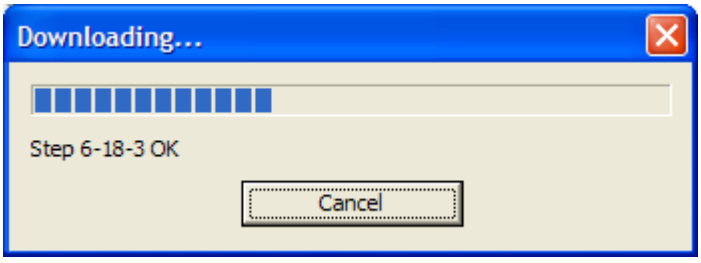
The "Run" Icon – Click to download to the MOACON and begin executing



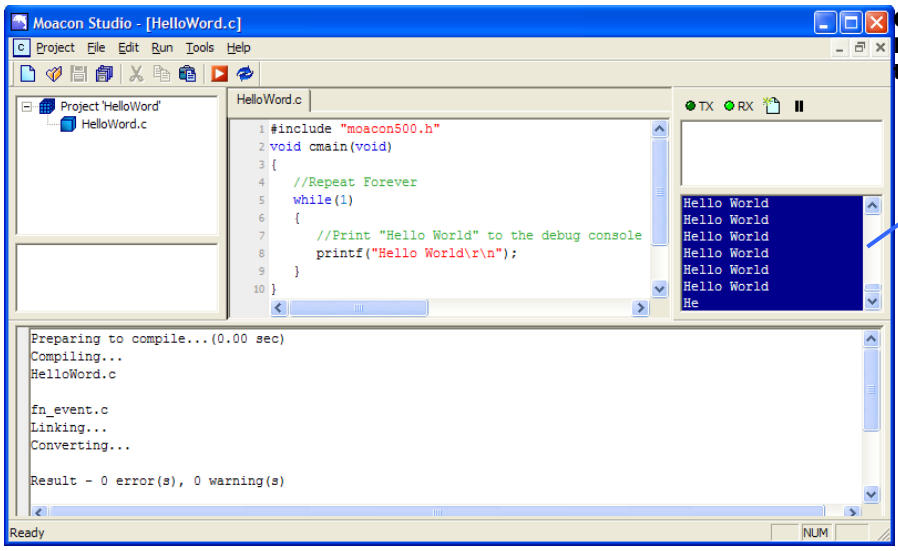
3. With the MOACON powered on, and connected to the PC via USB, click the "Run" icon ( ).

Output from the compiler will be displayed in the Output Window





4. MOACON Studio will compile the program and download it to the MOACON.



Output from the MOACON is displayed in the Debug Terminal

5. The MOACON will begin executing the program immediately. Output from the programs `printf` statement will be displayed in the Debug Terminal.

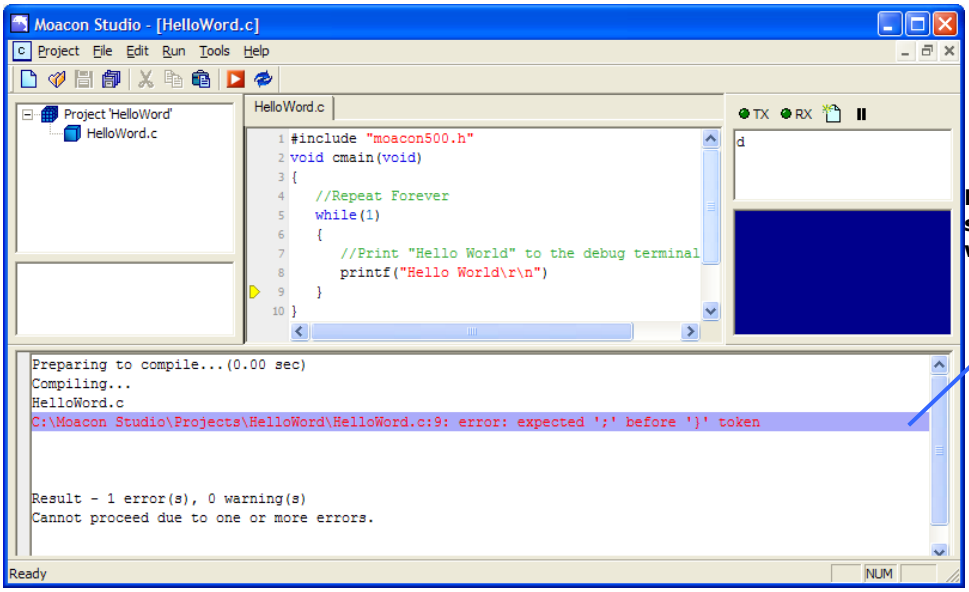
Note that the program is not running on the PC, it is running on the MOACON. If you disconnect the MOACON from the PC, there will be no output in the Debug Terminal.

Compiler Errors

Often during development, syntax errors and other errors can prevent a program from being compiled.

```
#include "moacon500.h"
void cmain(void)
{
    //Repeat Forever
    while(1)
    {
        //Print "Hello World" to the debug console
        printf("Hello World\r\n")   //ERROR: No semicolon
    }
}
```

For example, in the source above, there is no semicolon after the `printf` statement. This is a syntax error in C.

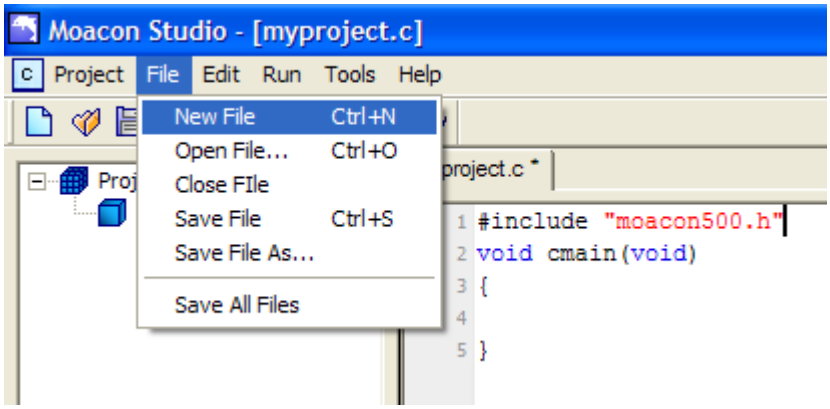


Double-Click to scroll to the line with the error.

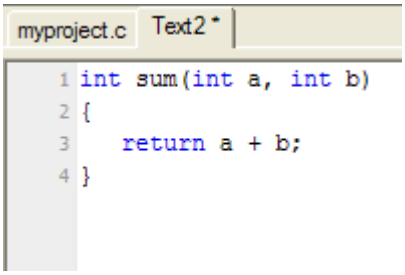
When the compiler encounters such an error, a message will be displayed in the output window. You can double-click the message in the output window, and the source editor will scroll to the line with the error.

Adding Source Files to a Project

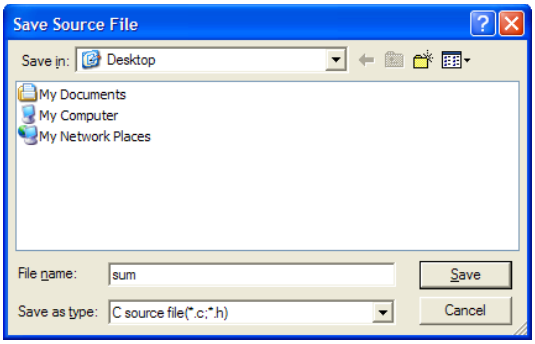
A project can contain many source files, and may be necessary to keep a large project organized. Follow the procedure below to add source files to a project.



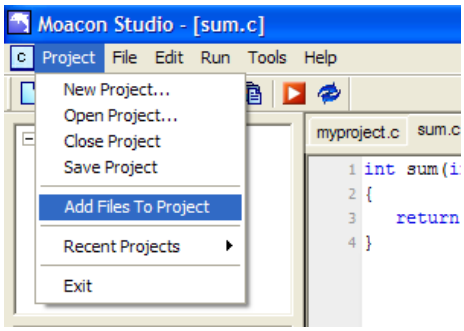
1. Choose "File" → "New File" from the menu. A new source file called "Text2" will appear in the source editor.



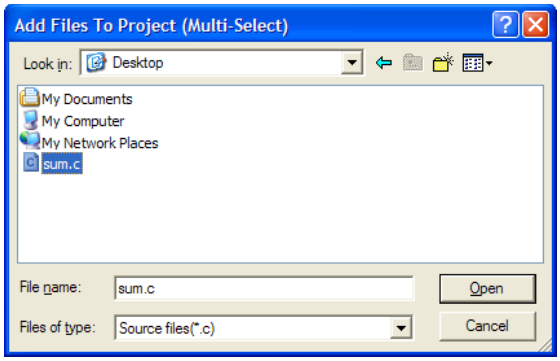
2. Enter some code.



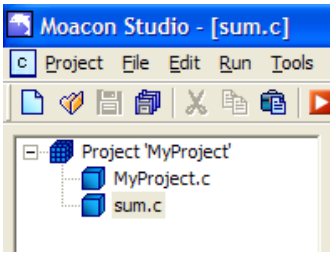
3. Save the file ("File" → "Save File"), and give it a new name. In the image above, the file name will be "sum.c".



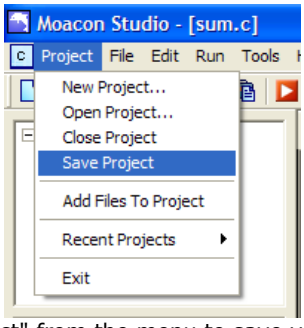
4. The file has now been saved, but is not yet part of the project. Choose "Project" → "Add Files To Project" from the menu.



5. Browse to the file to add, and click the "Open" button.



6. The new file will then appear in the Project View window. At this point, if you compile the project, all source files will be compiled.



7. Choose "Project" → "Save Project" from the menu to save your changes to the current project.

Debug Terminal

The Debug Terminal is an essential tool for displaying information on a program while it is executing. The following functions can be used to customize the way information is displayed in the Debug Terminal.

debugCls

void debugCls()

Clears all text in the debug terminal.

debugLocate

void debugLocate(x, y)

x: The cursor's x coordinate
y: The cursor's y coordinate

Moves the cursor to the position that is *x* characters from the left of the Debug Terminal, and *y* characters from the top of the Debug Terminal. This will be the point at which the next character will be printed.

debugPut

void debugPut(ch)

ch: The ASCII code of the character, or the character to be printed to the Debug Terminal

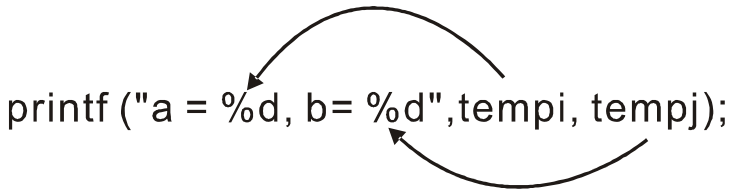
Prints a single ASCII character to the Debug Terminal. Both `debugPut('a')` and `debugPut(97)` print the character "a". 97 is the ASCII code for the character "a" in decimal.

printf

u32 printf(char *formatString[, arg0, ..., argn])

formatString: A character string to be printed that can optionally contain format specifiers
arg0,...,argn: An optional set of arguments to be used by format specifiers.
returns The number of characters printed.

Prints a string to the Debug Terminal. The string may optionally contain format specifiers that are substituted by the additional arguments (*arg0,..., argn*).



The MOACON supports the following format specifiers:

Specifier	Description	Prints
%d	Signed decimal integer	100 -10
%u	Unsigned decimal integer	100 12
%x	Unsigned lower case hexadecimal integer	Ab 12ab
%X	Unsigned upper case hexadecimal integer	AB 12AB
%c	A character	a
%f	A decimal floating point number	0.123534
%s	A string of characters	Comfile Technology
%e	Scientific notation	7.3458485e+07
%%	Escape '%' character	%

Examples:

```
int x=345;
float y=34.564;

printf("%10d\r\n",x);  // prints "       345"
printf("%-10d\r\n",x); // prints "345       "
printf("%010d\r\n",x); // prints "0000000345"
printf("%.2f\r\n",y);  // prints 34.57
```

`printf` is an extremely common output statement in the C programming language, and readers are encouraged to obtain additional C programming resources to learn more about this function.

Data Types

The MOACON Studio compiler supports the following data types:

`char`	Signed 8-bit number
`unsigned char`	Unsigned 8-bit number
`short`	Signed 16-bit number
`unsigned char`	Unsigned 16-bit number
`int`	Signed 32-bit number
`unsigned int`	Unsigned 32-bit number
`long`	Same as int
`unsigned long`	Same as unsigned int
`float`	32-bit floating point number (IEEE single-precision)
`double`	64-bit floating point number (IEEE single-precision)
`long long`	Signed 64-bit number

To make the syntax more compact, the following types have also been defined:

```
#define    u8    unsigned char
#define    u16   unsigned short
#define    u32   unsigned long
```

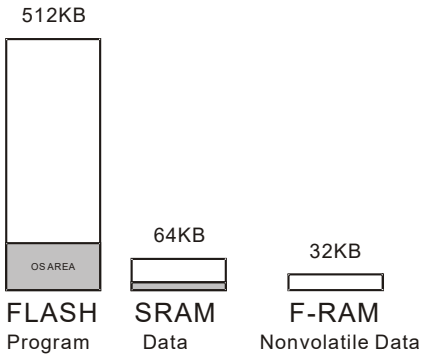
These types have already been pre-defined, so it is not necessary for users to define them. They can be used right out of the box.

```
void cmain(void)
{
    u8    i;    // 8-bit unsigned number
    u32   li;   // 32-bit unsigned number

    //...
}
```

Memory

The MOACON has 512KB of flash memory for executable code. However, some of this memory is consumed by the MOACON OS. The exact amount of memory depends on the MOACON OS version, but at the time this manual was written it was about 20KB.

The MOACON also has 64KB of data memory. Like the program memory, some of this is consumed by the MOACON OS. Again the exact amount consumed depends on the MOACON OS version, but at the time this manual was written it was about 10KB.



The size of the program can be determined when a program is compiled. If the program exceeds the amount of available memory, an "out of memory" error will occur.

The MOACON also has 32KB of non-volatile memory that is retained even when the MOACON is powered off. This memory can be accessed with the `framRead` and `framWrite` functions. The MOACON does not have a battery backup feature, so, if data must be retained between power cycles, be sure to store this data in FRAM.

Chapter 4
System Library

delay

void delay (u32 interval)

interval : Number of milliseconds to pause

Pauses execution for *interval* milliseconds. Please be aware that the accuracy of this function may vary and should not be used in situations where precise timing is needed.

```
#include "moacon500.h"

void cmain(void)
{
    portInit(2,0);          //Initialize ports 20~27 for output

    while(1)                //Run forever
    {
        portOut(20,1);      //Set port 20 High
        delay(100);         //Wait for 100ms

        portOut(20,0);      //Set port 20 Low
        delay(100);         //Wait for 100ms
    }
}
```

To wait for times less than 1ms, or to achieve a higher precision, a "spin-wait" function can be used. The CPU will spin in a loop for a specified number of iterations.

```
void spinWait(u32 countdown)
{
    for (;countdown > 0; countdown--);  //Loop until countdown reaches 0
}
```

Each iteration will consume a very small amount of time, so this method can be used to simulate a very short delay, or a delay with higher precision.

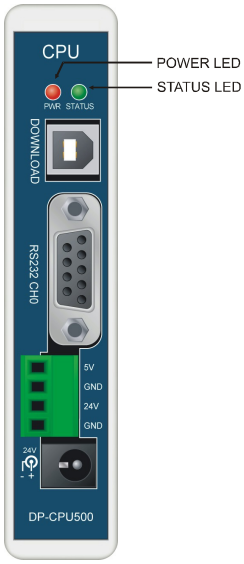
statusLed

void statusLed (u8 onoff)

onoff : 0=Off, 1=ON

Turns the status LED on the CPU Module on or off. Lighting or flashing the status LED is a simple way to convey the status of the system. The status LED is off by default.

```
statusLed(1);          //Turns the status LED On.
```



Real-Time Clock

The MOACON CPU Module has a built in Real-Time Clock (RTC). The chip contains a temperature sensor to compensate for drift due to temperature fluctuations. Please note, however, that although the MOACON's RTC is better than most, it is not 100% accurate.

The RTC is powered by a battery that keeps the RTC counting when no power is supplied to the MOACON. The battery's life span is approximately 10 years.

The following table illustrates the format in which the RTC data is stored in memory. Data is stored in Binary Coded Decimal (BCD).

RTC Address	Value	Range	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	Second	0 to 59		2nd digit			1st digit			
1	Minute	0 to 59		2nd digit			1st digit			
2	Hour	0 to 23			2nd digit		1st digit			
3	Day	1 to 7						1st digit		
4	Date	1 to 31			2nd digit		1st digit			
5	Month	1 to 12				2nd digit	1st digit			
6	Year	00 to 99	2nd digit				1st digit			

Days of the week (the "Day" field) are coded as shown in the following table

Sunday	1
Monday	2
Tuesday	3
Wednesday	4
Thursday	5
Friday	6
Saturday	7

The hour field ranges from 0 to 23 so one can distinguish between AM and PM.

rtcRead

u8 rtcRead (u8 rtcAdr)

rtcAdr : Address of the RTC data field (e.g. day, month, year, etc...) from which to read.

Reads the RTC value from the RTC data field's address, *rtcAdr*.

rtcWrite

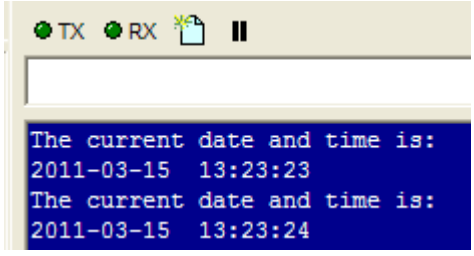
void rtcWrite(u8 rtcAdr, u8 rtcData)

rtcAdr : Address of the RTC data field (e.g. day, month, year, etc...) to set.
rtcData: Value to set

Sets the RTC data field at address *rtcAdr* to the value *rtcData*.

The following program sets the current date and time, and then prints the current date and time to the debug console.

```
#include "moacon500.h"

void cmain(void)
{
  //Set the current date and time
   rtcWrite(6, 0x11);    //2011-03-15 (March 15, 2011)
   rtcWrite(5, 0x03);
   rtcWrite(4, 0x15);

   rtcWrite(2, 0x13);    //01:17:23 pm
   rtcWrite(1, 0x17);
   rtcWrite(0, 0x23);

   while(1)            //Run forever
   {
        //Print the current date and time to the debug console
        printf("The current date and time is:\r\n");
        printf("20%02X-%02X-%02X  %02X:%02X:%02X\r\n", //yyyy-mm-dd hh:mm:ss
           rtcRead(6), rtcRead(5), rtcRead(4),         //year, month, day
           rtcRead(2), rtcRead(1), rtcRead(0));        //hour, minute, second

        delay(1000);
   }
}
```



FRAM Functions

The MOACON has 32KB of FRAM (Ferroelectric Random Access Memory) memory. It is non-volatile so it retains data even without power.

Retaining memory between power cycles has traditionally been implemented using EEPROMs or battery backup.

Battery backup uses a battery to maintain memory in internal SRAM. However, the battery must be monitored to ensure it has a charge and is replaced periodically, which places a maintenance burden on the operators.

EEPROMs incur a few milliseconds of latency when writing and are limited in the number of write-erase cycles.

FRAM can retain data for about 10 years without the need for a battery backup, has a lower writing latency, and has a greater maximum number of write-erase cycles.

framWrite

void framWrite(u16 fadr, u8 fData)

fAdr : Address in FRAM to write data
fData: Data to write

Writes *fData* to FRAM address *fAdr*. Addresses 0 through 0x7EFF are available for use. The last 256 bytes, addresses 0x7F00 through 0x7FFF, are reserved for the system and should not be used.

framRead

u8 framRead(u16 fadr)

fAdr : Address in FRAM to read from
returns the data read

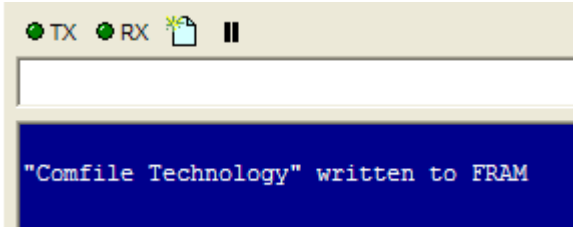
Gets a byte of data from FRAM address *fAdr*.

The following program demonstrates reading and writing to FRAM. If FRAM does not contain the string "Comfile Technology" at address 0, the string is written to FRAM. After writing to FRAM, if the MOACON is powered off and powered back on, the string will be retained.

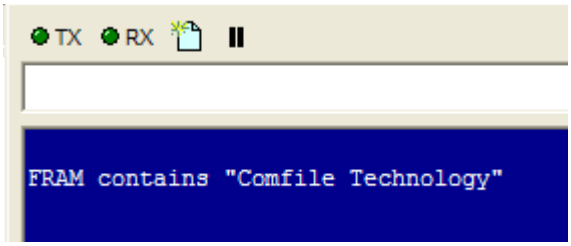
```
#include "moacon500.h"
#include <string.h>

void cmain(void)
{
  char text[STRING_LEN];

  const char* const comfile = "Comfile Technology";
  const u8 STRING_LEN = 19;     //"Comfile Technology" plus '\0' terminator

  u8 i = 0;
  for(i=0; i< STRING_LEN; i++)  //Clear text one character at a time
  {
```

```
      text[i] = '\0';
   }


  for(i=0; i<STRING_LEN-1; i++)          //Read data from FRAM one byte at a
  {                                      //time and store in variable text
     text[i] = framRead(i);
  }

  if (strcmp(text, comfile) != 0)        //If text does not equal comfile,
  {
       for(i=0; i<STRING_LEN-1; i++)      //write comfile to FRAM
       {                                  //one byte at a time
          framWrite(i, *(comfile+i));
       }
       printf("\"%s\" written to FRAM\r\n",
          comfile);
  }
  else                                   //if text equals comfile
  {
       printf("FRAM contains \"%s\"\r\n",
          comfile);
  }
}
```

The first time the program is run, "Comfile Technology" is written to FRAM.



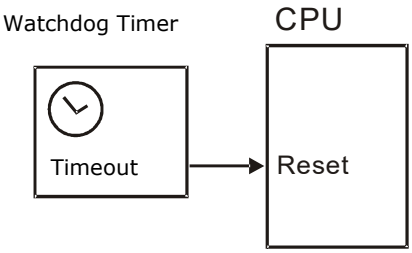
If the MOACON is powered off, and powered back on again, FRAM will still contain the string "Comfile Technology".



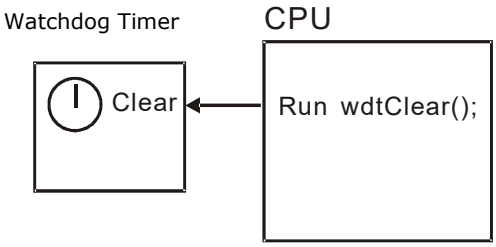
Watchdog Timer

A watchdog timer is a timer that triggers a system reset if the system does not service the timer before a specified timeout is reached.

The Watchdog timer will count up from 0 to a specified timeout. When the timeout is reached, it will reset the CPU.



To prevent the CPU from being reset, the watchdog timer must be cleared before the timeout is reached.



wdtOn

void wdtOn(u8 timeout)

timeout : A number corresponding to a specified timeout (0 ~ 6)

Enables the watchdog timer with a specified timeout, *timeout*. The following table maps *timeout* to a corresponding time span.

timeout	Time Span
0	≈ 0.4 seconds
1	≈ 0.8 seconds
2	≈ 1.6 seconds
3	≈ 3.2 seconds
4	≈ 6.5 seconds
5	≈ 13 seconds
6	≈ 26 seconds

Time Span is accurate within ±5%.

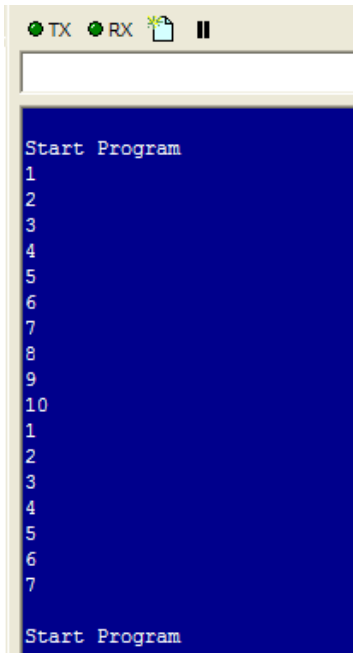
wdtClear

void wdtClear()

Resets the watchdog timer back to 0.

In the following program the watchdog timer is set to approximately 6.5 seconds. The first for-loop will be able to count to 10 because the watchdog timer is being cleared after each iteration. The second for-loop, however, will not be able to finish counting because the watchdog timer will reset the CPU after 6.5 seconds.

```
#include "moacon500.h"

void cmain(void)
{
  printf("Start Program\r\n");
   wdtOn(4);                  //Set watchdog timer to 6.5 seconds

  int i = 0;
   for(i=1; i<=10; i++)       //Count to 10
   {
       printf("%d\r\n", i);   //Print count to debug console
       delay(1000);           //Wait for 1 second

       wdtClear();            //Clear the watchdog timer
   }

   for(i=1; i<=10; i++)       //Try to Count to 10
   {
       printf("%d\r\n", i);   //Print count to debug console
       delay(1000);           //Wait for 1 second
   }
}
```



Timer

A timer triggers an event at a specified periodic interval. Intervals can be as long as 65 seconds or as short as 1ms.

startTimerEvent

void startTimerEvent(u16 interval)

interval : The amount of time between each event in milliseconds (1 ~ 65,535)

Starts a timer that triggers events every *interval* milliseconds.

These timers can be used to trigger background processes at regular intervals, thus simulating multitasking.

Care must be taken when using these timers. **The process triggered by the event, i.e. service routine, must execute in less time than the timer's interval**. If the service routine cannot finish in time, the system will never be able to exit out to the main routine.

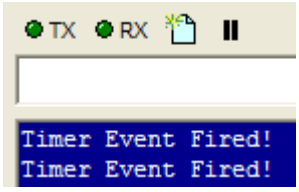
timerEvent

void timerEvent()

This is the function that is called when a timer's event fires.

The following program demonstrates how to use the `startTimerEvent` function with the `timerEvent` function.

```
#include "moacon500.h"

void cmain(void)
{
   startTimerEvent(500);                  //Execute timerEvent() every 500ms

    while(1)                               //Run forever
    {
       delay(2000);                        //Pause for 2 seconds
    }
}

void timerEvent()
{
    printf("Timer Event Fired!\r\n");      //Print to the debug console
}
```



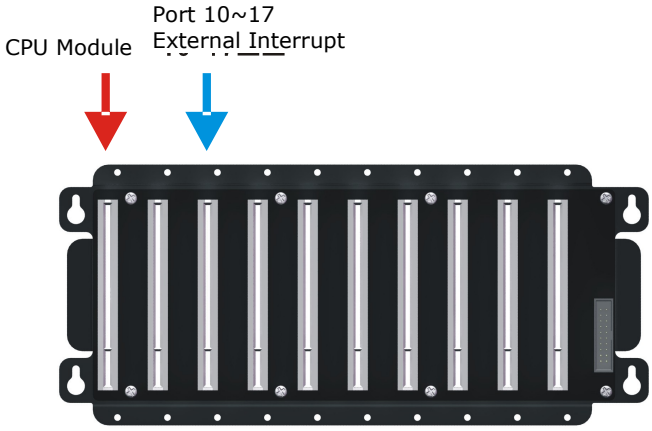
stopTimerEvent

void stopTimerEvent()

Stops the timer.

External Interrupts

The MOACON has the ability to receive external interrupts on ports 10 through 17. When an interrupt is received, an interrupt service routine (ISR) is executed. A Digital Input Module can be installed in slot +10 to receive interrupt signals.



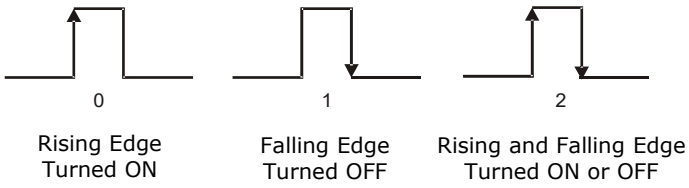
startExtIntEvent

void startExtIntEvent(u8 extIntPort, u16 extIntType)

extIntPort : The port to use as an external interrupt port (10~17)

extIntType: 0=Rising Edge, 1=Falling Edge, 2=Rising and Falling Edge

Tells the MOACON to configure *extIntPort* as an external interrupt port. *extIntType* configures the interrupt to trigger when turned on (0), when turned off(1), or when turned on or off (2).



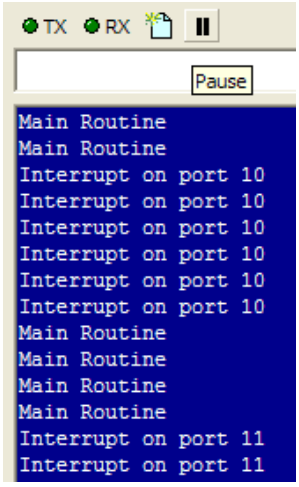
extIntEvent

void extIntEvent(u8 extIntPort)

extIntPort : The port on which the interrupt was triggered

The interrupt service routine for the external interrupts. This function is executed when any of the external events are triggered. *extIntPort* is the port on which the external interrupt was triggered.

```
#include "moacon500.h"
void cmain(void)
{
   startExtIntEvent (10,0);  //Port 10, triggerd on rising edge
   startExtIntEvent (11,2);  //Port 11, triggered on rising and falling edge

   while(1)                  //Run forever
   {
      printf("Main Routine \r\n");
      delay(1000);
   }
}

void extIntEvent(u8 extIntPort)
{
   switch(extIntPort)
   {
     case 10:   //If event was triggered on port 10
        printf("Interrupt on port 10 \r\n");
        break;

     case 11:   //If event was triggered on port 11
        printf("Interrupt on port 11 \r\n");
        break;
   }
}
```



stopExtIntEvent

void stopExtIntEvent(u8 extIntPort)

extIntPort : The port to stop using as an external interrupt (10~17)

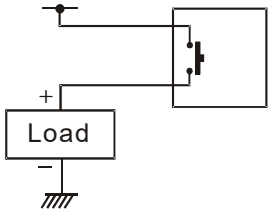
Stops using port *extIntPort* as an external interrupt.

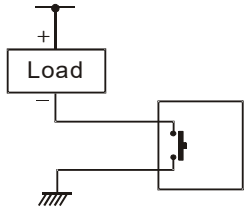
Chapter 5
Digital I/O Modules

Source and Sink Outputs

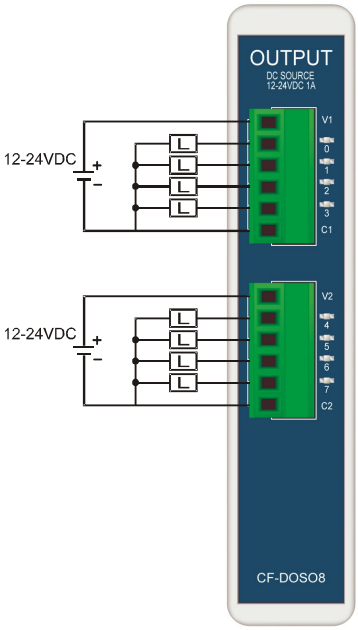
The MOACON Digital I/O Modules come in 2 flavors: the Source Output Module, and the Sink Output Module.

Source Output	Sink Output
When turned on, the load's positive terminal is connected to the positive supply rail.	When turned on, the load's negative terminal is connected to the negative supply rail.

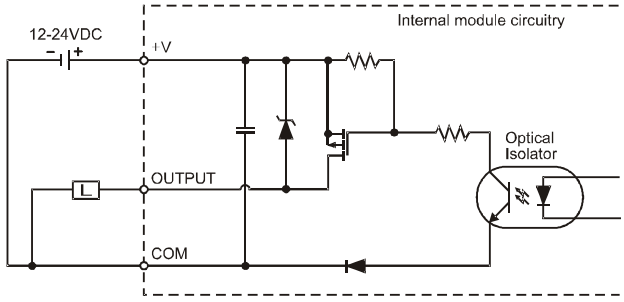




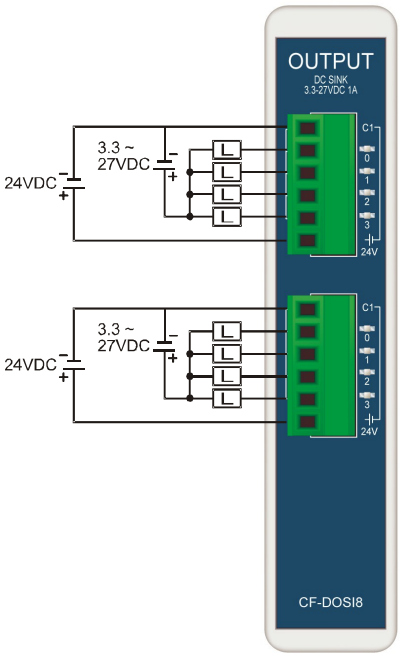
8-Port DC Source Output Module



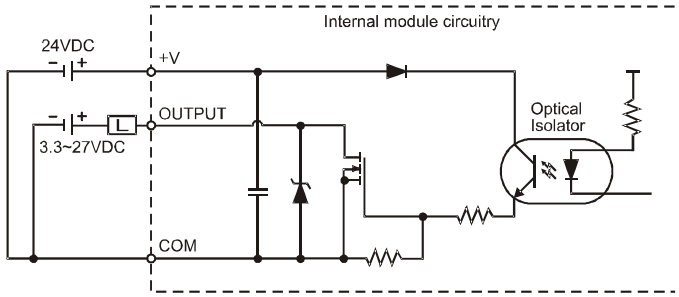
CF-DOSO8 Specifications	
Ports	8
Operating Voltage	12 – 24VDC
Output Voltage	10 – 30VDC
Maximum Output Current	1A / Port, 4A / COMMON
Minimum Output Current	0.5mA
Maximum On/Off switching frequency	1KHz (1000 times per second)
Status LED	Lights when port is ON
Common Terminals	2 (independent)



8-Port DC Sink Output Module



CF-DOSI8 Specifications	
Ports	8
Operating Voltage	3.3 – 27 VDC
Output Voltage	3 – 30VDC
Maximum Output Current	1A / Port, 4A / COMMON
Minimum Output Current	0.5mA
Maximum On/Off switching frequency	1KHz (1000 times per second)
Status LED	Lights when port is ON
Common Terminals	2 (independent)

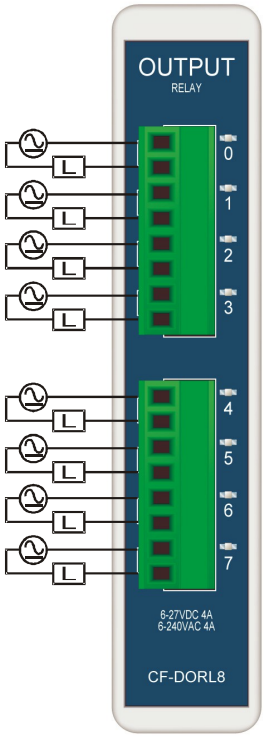


The Sink Output module requires two power sources. The DC 24V power source is used to drive the internal FET.

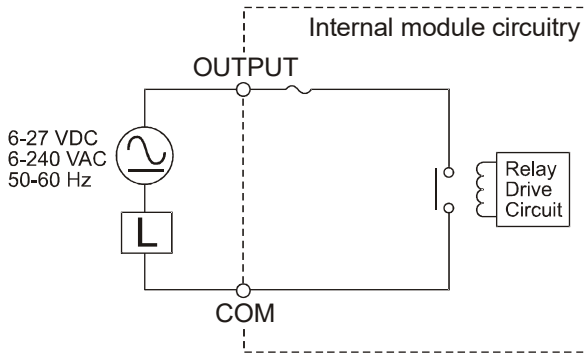
The Sink Output Module has a wider output voltage range than the Source Output Module.

DC Output Modules can output a pulse of up to 1KHz meaning it can be switched on and off at about 1000 times per second.

8-Port Relay Output Module



CF-DORL8 Specifications	
Ports	8
Operating Voltage	6-27VDC / 6-240VAC
Output Voltage	5-30VDC / 5-264 VAC
Maximum Output Current	4 A / Port, 4A / COMMON
Minimum Output Current	100 mA @ 5VDC
Maximum On/Off Switching Frequency	25Hz (25 times per second)
Status LED	Lights when port is ON
Common Terminals	8 (Independent)



This is a 4A load per port relay output module capable of up to AC 240V.

If a high switching frequency is needed, using the DC Output Modules is recommended.

After prolonged used, the relay's mechanical contacts may become worn and will need to be replaced. (Individual relays are not available, so the entire module will need to be replaced).

Digital Output Module Library

portInit

void portInit(u8 portBlockNumber, u8 mode)

portBlockNumber: Port Block Number (e.g. 0 for ports 0~7, 1 for ports 10~17, etc...)
mode: 0 or 1 (0=Output, 1=Input)

Intitializes a port block's I/O mode as either Input or Output. In order to use a port for output, its I/O mode must be changed to Output. Likewise, in order to use a port for input, its I/O mode must be changed to Input.

Ports are initialized to Input when the system is first powered on.

The MOACON ports' I/O mode can only be set in blocks. The MOACON's ports are organized in blocks of 8.

Block Number	Block 0 (+0)	Block 1 (+10)	Block 2 (+20)	Block 3 (+30)	Block 4 (+40)	Block 5 (+50)
Ports	Ports 0 - 7	Ports 10 - 17	Ports 20 - 27	Ports 30 - 37	Ports 40 - 47	Ports 50 - 57

Setting *mode* to 0 will put the port block in Output mode, and setting *mode* to 1 will put the port block in Input mode.

In the image above there are 3 output modules and 3 input modules. The following code would be used to set the ports' I/O mode for this configuration.

```
portInit(0,0);    // Block 0 in Output mode
portInit(1,0);    // Block 1 in Output mode
portInit(2,0);    // Block 2 in Output mode
portInit(3,1);    // Block 3 in Input mode
portInit(4,1);    // Block 4 in Input mode
portInit(5,1);    // Block 5 in Input mode
```

Because ports are initialized to Input when the system is first powered on, this code can be reduced to the following:

```
portInit(0,0);    // Block 0 in Output mode
portInit(1,0);    // Block 1 in Output mode
portInit(2,0);    // Block 2 in Output mode
```

Port blocks 3, 4, and 5 are in Input mode by default.

portOut

void portOut (u16 portNumber, u8 value)

portNumber : Port Number of an individual port (not a port block)
value : 0 or 1 (0=Off, 1=On)

Sets *portNumber*'s output state on (value=1) or off (value= 0). The port block containing the given port, *portNumber*, must have its I/O mode set to Output beforehand.

```
portOut(20,1);    // Turns port 20 on
portOut(20,0);    // Turns port 20 off
```

portBlockOut

void portBlockOut (u8 portBlockNumber, u8 value)

portBlockNumber : Port block number (0 through 5)
value : 0 through 255

Sets the output state of all ports in the given port block, *portBlockNumber*. *value* is a bit array corresponding to the 8 individual ports in the port block. If *portBlockNumber* were 1, *value*'s bit 0 would correspond to port 10 and *value*'s bit 7 would correspond to port 17.

```
portBlockOut(1,7);      // Ports 10-12: ON, Ports 13-17 OFF
                        // 7 = b0000 0111
```

portOff

void portOff (u16 portNumber)

portNumber : The port number to turn off

Sets the output state of the given port, *portNumber*, to off.

```
portOff(20); // Turns port 20 off
```

portOn

void portOn (u16 portNumber)

portNumber : The port number to turn on

Sets the output state of the given port, *portNumber*, to on.

```
portOn(20);  // Turns port 20 on
```

portReverse

void portReverse (u16 portNumber)

portNumber : The port number to toggle

Toggles the output state of the given port, *portNumber*.

```
portOn(20);      // Turns port 20 on
portReverse(20); // Turns port 20 off
portReverse(20); // Turns port 20 back on
```

portOutStat

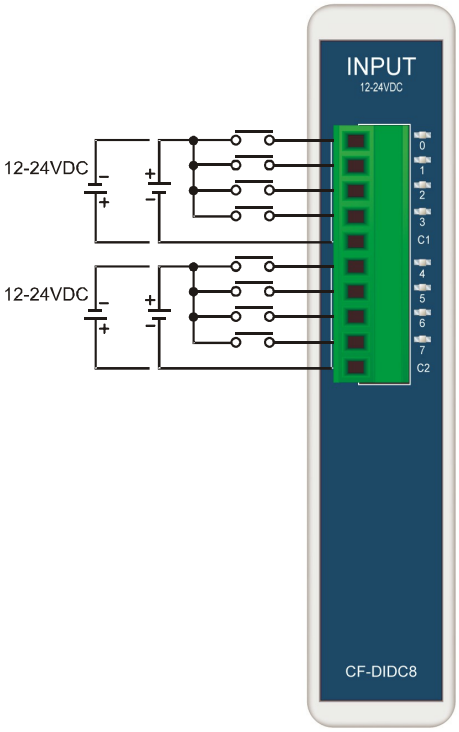
void portOutStat (u16 portNumber)

portNumber : The port number to toggle

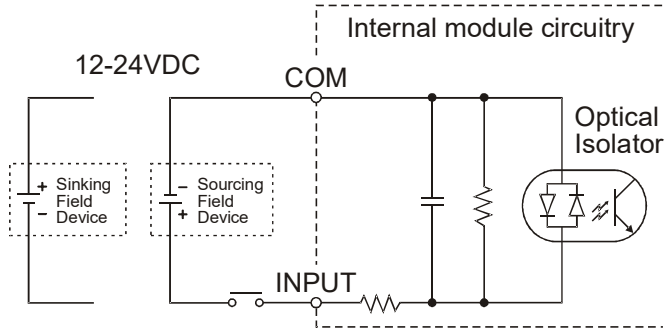
Reads the current output state of *portNumber*.

```
u8 state = portOutStat(20);  // Reads the current output state of port 20
```

8-Port Digital Input Module



CF-DIDC8 Specifications	
Ports	8
Operating Voltage	12 –24VDC
Input Voltage Range	11V – 26VDC
Input Current	Approx. 5mA @ 24VDC
ON/ OFF Response	3ms
Input Impedance	4.7KΩ @ 24VDC
OFF Level	< 6.2VDC
ON Level	> 7.2VDC



Digital Input Module Library

portIn

u8 portIn (u16 portNumber)

portNumber : The port number from which to read
returns the input state of *portNumber*

Reads the input state of the given port, *portNumber*. If the voltage on the port is less than the module's Off Level, `portIn` returns 0 (Off). If the voltage on the port is greater the module's On Level, `portIn` returns 1 (On).

```
u8 i = portIn(20);      // Reads the input state of port 20 and stores the
                        // result in variable i
```

portBlockIn

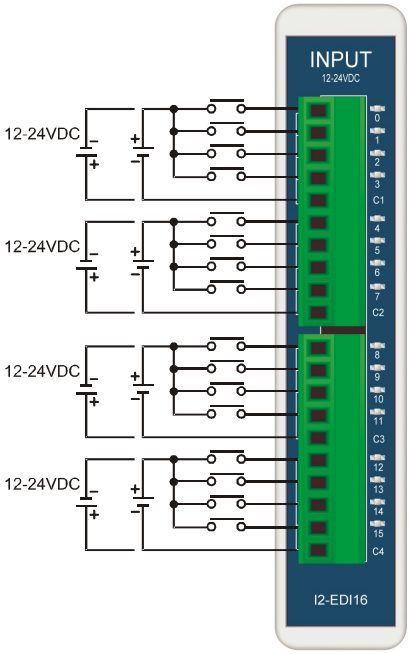
u8 portBlockIn (u8 portBlockNumber)

portBlockNumber : The port block to read (0 through 5)
returns a bit array containing the input state of each port in *portBlockNumber*

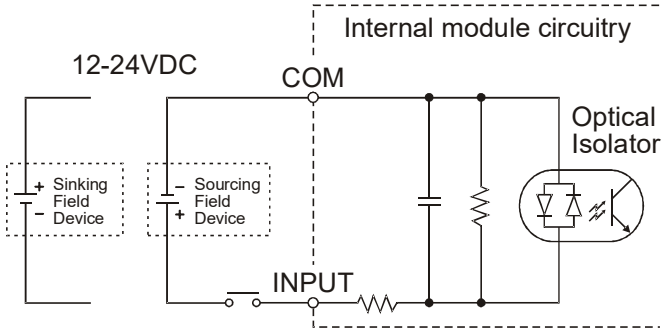
Reads the input state of all ports in the given port block, *portBlockNumber*, returning a 8-bit array containing the input state of each of the 8 ports in the port block. If *portBlockNumber* is 1, bit 0 of the return value would correspond to port 10, and bit 7 would correspond to port 17. If `portBlockIn(1)` returned a value of 7 (b0000 0111), this would mean ports 10~12 would be on, and ports 13-17 would be off.

```
u8 i = portBlockIn(20);     // Reads the input state of ports 20 ~ 27
```

16-Port Digital Input Expansion Module



I2-EDI16 Specifications	
Ports	16
Operating Voltage	12 –24VDC
Input Voltage	11V – 26VDC
Input Current	Approx. 5mA @ 24VDC
ON/ OFF Response	3 ms
Input Impedance	4.7KΩ @ 24VDC
OFF Level	< 7.4VDC
ON Level	> 7.5VDC



The DIP switch on the side of the module is used to assign the module to a port block.

DIP Switch	Port Block	Port Number
1 2 3 OFF ON	0	0x00 ~0x0F
1 2 3 OFF ON	1	0x10 ~0x1F
1 2 3 OFF ON	2	0x20 ~0x2F
1 2 3 OFF ON	3	0x30 ~0x3F

DIP Switch	Port Block	Port Number
1 2 3 OFF ON	4	0x40 ~0x4F
1 2 3 OFF ON	5	0x50 ~0x5F
1 2 3 OFF ON	6	0x60 ~0x6F
1 2 3 OFF ON	7	0x70 ~0x7F

Digital Input Expansion Module Library

eportIn

u8 eportIn (u16 eportNumber)

eportNumber : The expansion port number from which to read
returns the input state of *eportNumber*

Reads the input state of the given expansion port, *eportNumber*. If the voltage on the port is less than the module's Off Level, `portIn` returns 0 (Off). If the voltage on the port is greater the module's On Level, `portIn` returns 1 (On).

```
u8 i = eportIn(0x10);  // Reads the input state of port 0x10 and stores the
                       // result in variable i
```

eportBlockIn

u16 eportBlockIn (u8 eportBlockNumber)

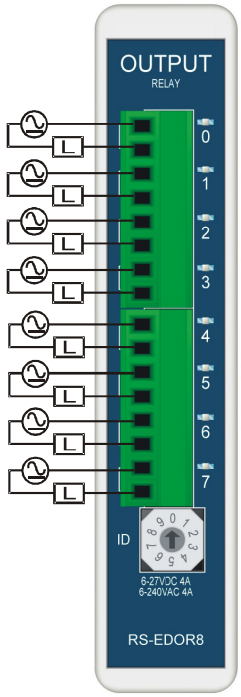
eportBlockNumber : The expansion port block to read (0 through 5)
returns a bit array containing the input state of each port in *portBlockNumber*

Reads the input state of all ports in the given expansion port block, *eportBlockNumber*, returning a 16-bit array containing the input state of each of the 16 ports in the port block. If *eportBlockNumber* is 0x10, bit 0 of the return value would correspond to port 0x10, and bit 15 would correspond to port 0x1F. If `eportBlockIn(1)` returned a value of 257 (b0000 0001 0000 0001), this would mean ports 0x10 and 0x18 would be on, and the other 14 ports would be off.

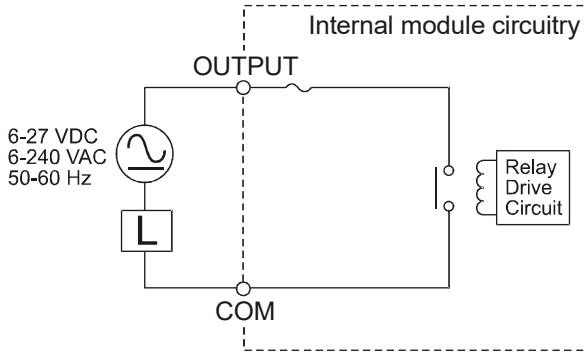
```
u8 i = eportBlockIn(0x10);  // Read input state of ports 0x10 ~ 0x1F
```

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Port (Hex)	1F	1E	1D	1C	1B	1A	19	18	17	16	15	14	13	12	11	10

8-Port Relay Output Expansion Module



RS-EDOR8 Specifications	
Ports	8
Operating Voltage	6-27VDC / 6-240VAC
Output Voltage	5-30VDC / 5-264 VAC
Maximum Output Current	4 A / Port, 4A / COMMON
Minimum Output Current	100 mA @ 5VDC
Maximum On/Off Switching Frequency	10Hz (10 times per second)
Status LED	Lights when port is ON
Common Terminal	8(Independent)



The rotary switch on the face of the module is used to assign the module to a port block.

ID (Port Block)	Output Ports
0	0 ~ 7
1	10 ~17
2	20 ~ 27
3	30 ~ 37
4	40 ~ 47
5	50 ~ 57
6	60 ~ 67
7	70 ~ 77
8	80 ~ 87
9	90 ~ 97

Relay Output Expansion Module Library

eRelay

void eRelay (u16 eportNumber, u8 value)

eportNumber : The expansion port number of an individual port (not a port block)
value : 0 or 1 (0=Off, 1=On)

Sets *eportNumber*'s output state on (value=1) or off (value= 0).

```
eRelay(60,1);     // Turns port 60 on
eRelay(60,0);     // Turns port 60 off
```

eRelayBlock

void eRelayBlock (u16 eRelayID, u8 value)

eRelayID : The module's ID (port block number) (0 through 9)
value : 0 through 255

Sets the output state of all ports in the given port block, *eRelayID*. *value* is a bit array corresponding to the 8 individual ports in the port block. If *eRelayID* were 1, *value*'s bit 0 would correspond to port 10 and *value*'s bit 7 would correspond to port 17.

```
eRelayBlock(1,7);      // Ports 10-12: ON, Ports 13-17 OFF
                       // 7 = b0000 0111
```

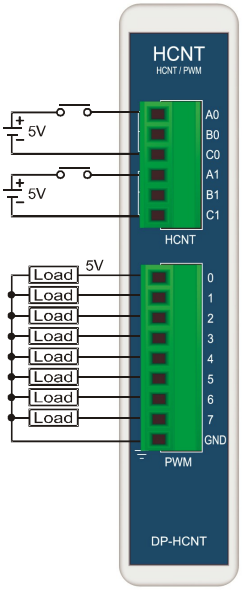
*Keep in mind the Expansion Relay Output Module's maximum on/off switching speed is 10 times a second (10Hz).

Chapter 6 High-Speed Counter Module

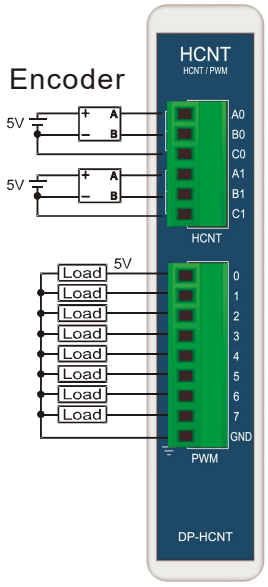
High-Speed Counter Module

The high-speed counter module features high-speed counter input (or encoder input), and PWM outputs. Unlike other MOACON I/O modules, care needs to be taken to ensure signals stay within 0 ~ 5V.

High-Speed Counter Input

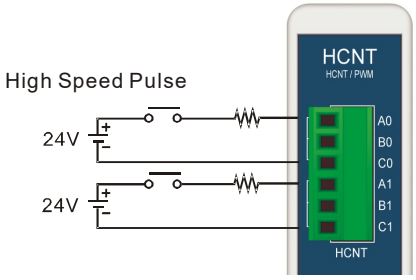


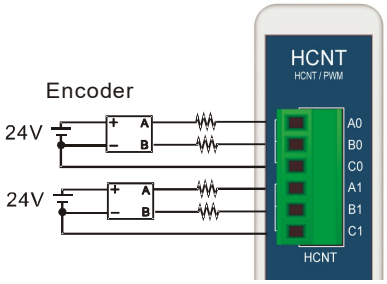
Encoder Input



Input signals should be within 0 ~ 5V. (2V and greater is a Logic High)

When inputting between 12V ~ 24V connect a 2.2kΩ (0.5W) resistor in series.





High-Speed Counter Module Library

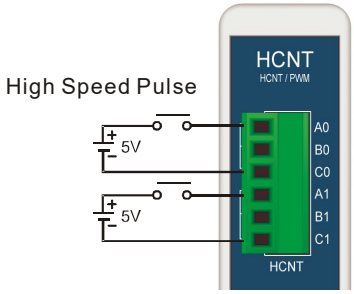
countMode

void countMode (u8 cntChannel, u8 cntMode)

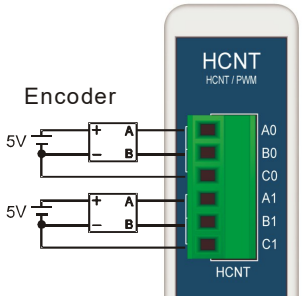
cntChannel : Channel number (0 or 1 for DP-HCNT)
cntMode : Operation mode (0: basic counter, 1: encoder counter)

cntMode 0: basic counter increments on both the rising and falling edge of the input.
cntMode 2: basic counter increments on the rising edge of the input.
cntMode 3: basic counter increments on the falling edge of the input.
cntMode 1: encoder counter that counts up or down based on the phase difference between A and B

When *cntMode* is 0, 2, or 3 the channel functions as a basic counter. The module reads from port A (A0 for channel 0, A1 for channel 1). When in this mode, nothing should be connected to port B (B0 for channel 0, B1 for channel 1).



When *cntMode* is 1, the channel functions as an encoder counter.



The module counts up or down based on the phase difference between A and B. If A leads B, the counter counts up. If B leads A, the counter counts down.

`countMode` will always initialize the count to 0. The count will roll over (65,535 to 0 if increasing, and 0 to 65,535 if decreasing) when the count exceeds 65,535 (16 bit maximum) or falls below 0.

count

u16 count (u8 cntChannel)

cntChannel : Channel number (0 or 1 for DP-HCNT)
returns the current value of the counter on channel, *cntChannel*.

Reads the current value of the counter on channel, *cntChannel*. The counter counts independently of the processor, so while other parts of the program may be running, the counter is still counting. Calling `count` returns the current value in the counter.

```
countMode(0,0);       // Set channel 0 to function as a basic counter
u16 cnt = count(0);  // Read current count from channel 0
```

```
countMode(0,1);       // Set channel 0 to function as an encoder counter
u16 cnt = count(0);  // Read current count from channel 0
```

If reading signed values is desired, the return value should be interpreted in 2's complement (-1 = 0xFFFF) and should be stored as a singed 16 bit integer (`short` data type). 16 bit signed integers have a range of –32,768 to 32,767.

```
countMode(0,1);         // Set channel 0 to function as an encoder counter
short cnt = count(0);  // Read current count from channel 0 (signed numbers)
```

If you need to scale the counter to support higher count values, use the `countPrescaler` function.

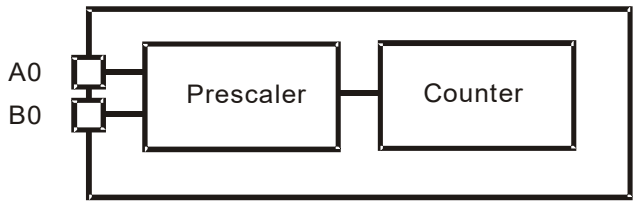
countPrescaler

void countPrescaler (u8 cntChannel, u16 prescaleValue)

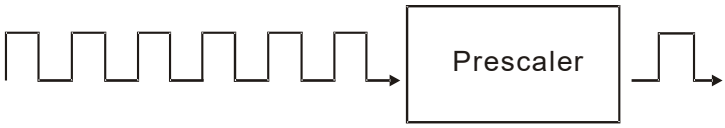
cntChannel : Channel number (0 or 1 for DP-HCNT)

prescaleValue: 0 ~ 65,535

Scales the counter to support a higher count by dividing the count by a prescale value, *prescaleValue*. The default prescale value is 0, which is division by 1 (i.e. each pulse will increment/decrement the counter by 1). Therefore, the divisor is equal to *prescaleValue* + 1.



If *prescaleValue* is 5, the divisor would then be 5+1=6 meaning every 6 pulses will increment/decrement the counter by 1.



`countPrescaler` initializes the counter to 0.

countReset

void countReset(u8 cntChannel)

cntChannel : Channel number (0 or 1 for DP-HCNT)

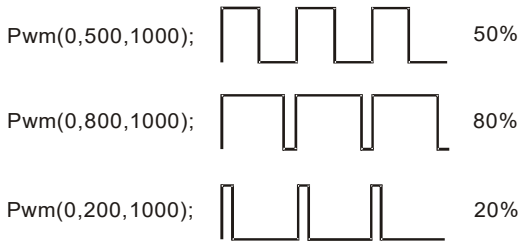
Initializes the counter on channel *cntChannel* to 0.

pwm

void pwm(u8 pwmChannel, u16 pwmDuty, u16 pwmWidth)

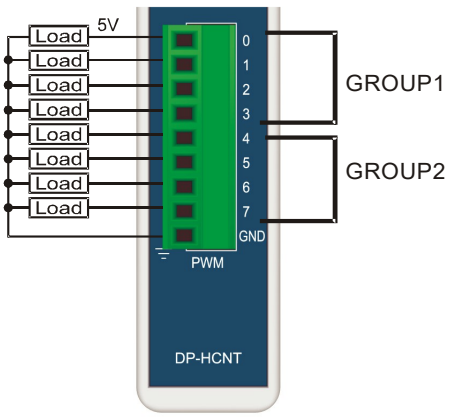
pwmChannel : PWM channel
pwmDuty: Duration for which the pulse is ON
pwmWidth: Pulse period

Sets the duty cycle and period of the pulse width modulator (PWM) on channel *pwmChannel*. *pwmWidth* specifies the width of an entire pulse (i.e. the pulse period) and *pwmDuty* specifies the duration for which the pulse is ON. This, therefore, implies that *pwmDuty* should always be less than *pwmWidth*.



The pulse is started once `pwm` is called. `pwmOff` is used to turn off the pulse.

The High-Speed Counter Module has a total of 8 PWM channels. The channels, however, are organized into two groups. Each group's period (*pwmWidth*) must be the same.




```
pwm(0, 10, 400);
pwm(1, 40, 400);
pwm(2, 200, 400);
pwm(3, 350, 400);

pwm(4, 1000, 1024);
pwm(5, 160, 1024);
pwm(6, 80, 1024);
pwm(7, 10, 1024);
```

The PWM's frequency can be determined by the following formula:

$$frequency = \frac{72{,}000{,}000}{pwmWidth}$$

For a *pwmWidth* of 65,535, the frequency would be 1099Hz.

```
pwm(0, 32768, 65535 );  // A 1099Hz pulse
```

Please note that this formula is just an approximation, so when precision is needed, the actual frequency should be measured and adjusted as necessary.

pwmOff

void pwmOff(u8 pwmChannel)

pwmChannel : PWM channel

Stops the pulse on channel *pwmChannel*.

freqOut

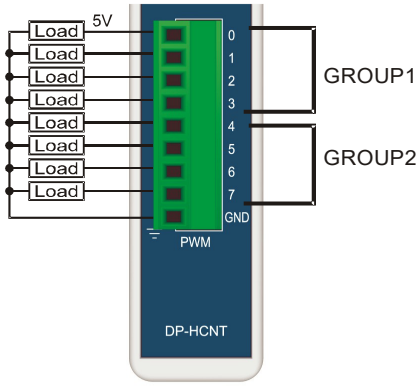
void freqOut (u8 pwmChannel, u32 freqVal)

pwmChannel : PWM channel

freqValue: Approximate frequency

Creates a pulse on PWM channel *pwmChannel* of frequency *freqValue*.

`freqOut` can only be used on one channel in a group at a time. The High-Speed Counter Module has 2 PWM groups, so 2 waveforms with different frequencies can be created.




```
FreqOut (0, 440);
```

Creates a waveform of approximately 440Hz on PWM channel 0. `pwm` functions cannot be used on channels 1, 2, or 3.

```
FreqOut (5, 30000);
```

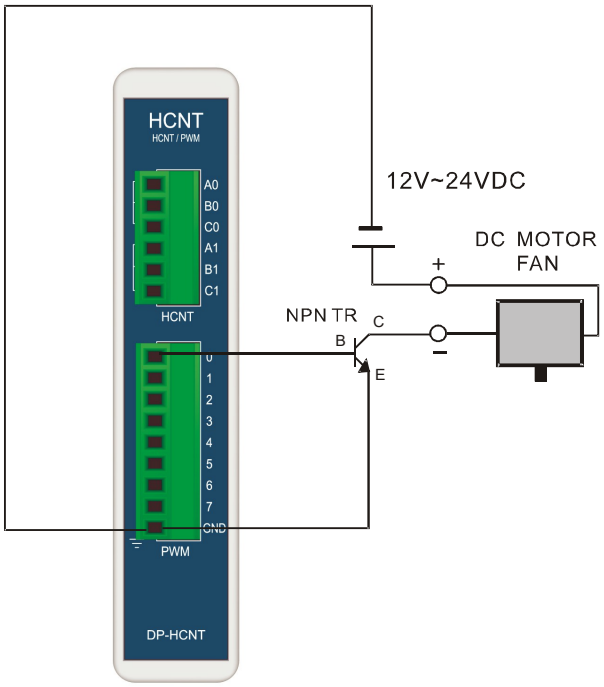
Creates a waveform of approximately 30kHz. `pwm` functions cannot be used on channels 4, 6, or 7.

`freqOut` is just a specialized form of the `pwm` function, so to turn off the pulse, use the `pwmOff` function.

```
freqOut(0,435);  // Create a 435Hz pulse on PWM channel 0
delay(1000);     // Run the pulse for 1 second
pwmoff(0);       // Turn off the pulse
```

Using the PWM Output

The 5V PWM output does not provide much current to drive certain loads. An NPN transistor can be used as shown below to provide more current to loads such as a DC fan motor.



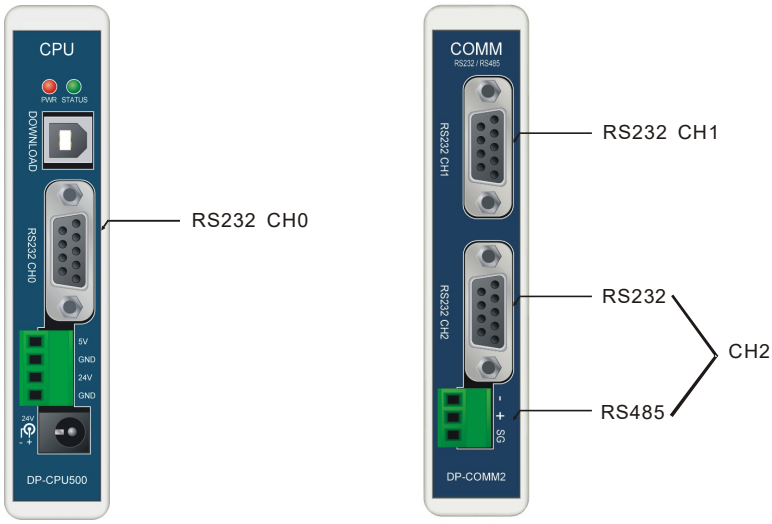
The transistor will have to be one that can bear the load of the motor. A heat sink may be needed to keep the transistor from overheating.

MEMO

Chapter 7 Communication Module

Communication Module

The MOACON can support up to 3 RS-232/485 channels. One (channel 0) is built into the CPU Module. Channels 1 and 2 can be found on the Communication Module.



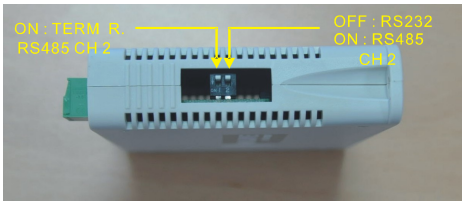
CPU Module Communication Module

Channel 0 can be used with Comfile Tehnology's User Interface Panels (e.g. UIF-420A). It includes a 5V power source on pin 9 that can be turned on and off with the `comPower` function.

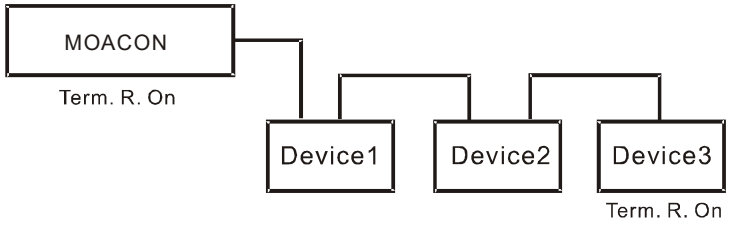
RS-232 pin configuration is shown in the image below. Like channel 0, channels 1 and 2 have a 5V power source on pin 9, but unlike channel 0, it cannot be turned off.

1
2(TXD)
3(RXD)
4
5(GND)
6
7
8
9 (5V)

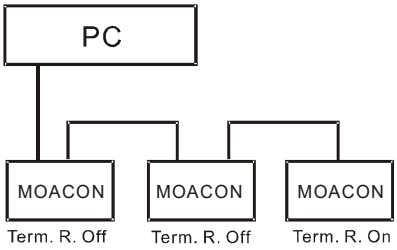
On the Communication Module, channel 1 is dedicated to RS-232, but channel 2 can be switched between RS-232 and RS-485.



If the MOACON is used as a master in an RS-485 network, be sure to turn the RS-485 terminator (DIP Switch 1) ON as shown in the image below.



If several MOACONs are used as slaves in an RS-485 network, only the MOACON located at the end needs its terminator turned ON.



Generally, when using RS-485, users need to manage the "Transmit Enable" signal. The MOACON, however, manages this internally, so the user doesn't have to. All MOACON RS-232 send and receive signals are ±12V.

Communication Module Library

openCom

void openCom (u8 comCh, u32 comBaud, u8 comMode)

comCh : Channel number
comBaud : Baud rate
comMode: Communication mode (data bits, parity, and stop bits)

Opens the port on channel *comCh* with the given baud rate, *comBaud*, and the communication mode, *comMode*.

comBaud is the baud rate. It can be set to any value between 300 and 115200, but generally it is set to one of the following values.

1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200

comMode sets the number of data bits, stop bits, and parity for the port. Several constants have been predefined to make this argument easier to set and understand. They are shown in the table below.

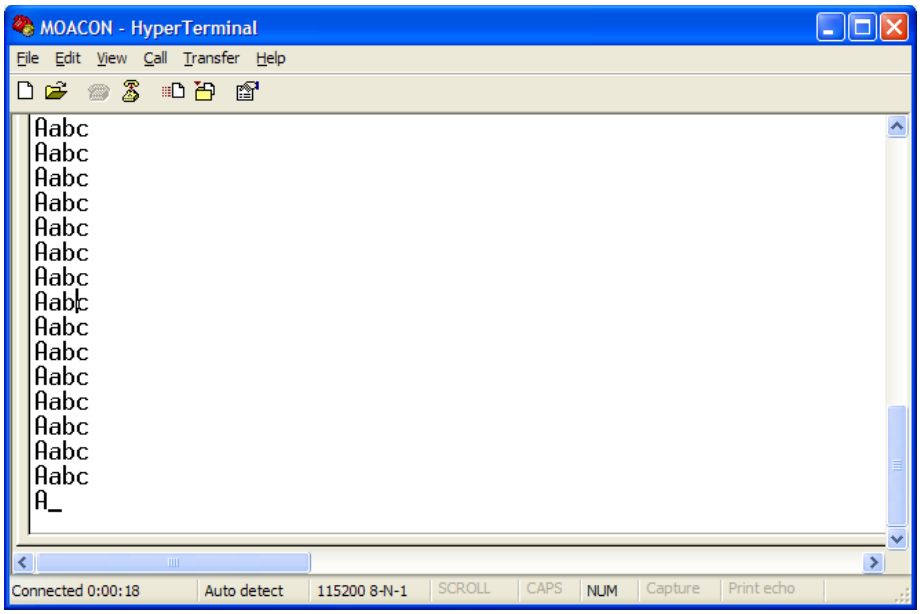
comMode	Data Bits	Parity	Stop Bits
C7E1	7	EVEN	1
C7O1	7	ODD	1
C8N1	8	NONE	1
C8E1	8	EVEN	1
C8O1	8	ODD	1
C7E2	7	EVEN	2
C7O2	7	ODD	2
C8N2	8	NONE	2
C8E2	8	EVEN	2
C8O2	8	ODD	2

`openCom` clears and allocates 255 bytes for the receive buffer. The receive buffer's size cannot be set by the user.

The following is a sample programming demonstrating the use of `openCom`.

```
#include "moacon500.h"
void cmain(void)
{
   openCom(0, 115200, C8N1);         // Channel 0, 115200 Baud,
                                     // data bits: 8, no parity, stop bits: 1

   while (1)                         // Repeat forever
   {
         delay(500);                 // Wait for 500ms
         comPrint(0,"abc\r\n");      // transmits "abc" and a new line
         comPut(0,0x41);             // transmits the letter 'A' (ASCII 0x41)
   }
}
```

Connect a PC to MOACON's RS-232 channel 0 and use HyperTerminal to view the output.



comPut

void comPut (u8 comCh, u8 comChar)

comCh : Channel number
comChar : Byte to transmit

Transmits a single byte, *comChar*, on channel *comCh*. To send ASCII characters, *comChar* should be the character's ASCII code.

```
#include "moacon500.h"
void cmain(void)
{
  openCom(0, 115200, C8N1);      // Channel 0, 115200 Baud,
                                 // data bits: 8, no parity, stop bits: 1

  while (1)                      // Repeat forever
  {
      delay(500);                // Wait for 500ms
      comPut(0,0x41);            // transmits the letter 'A' (ASCII 0x41)
      comPut(0,'B');             // transmits the letter 'B'
  }
}
```

A character's ASCII code can be specified using a numeric literal (e.g. `0x41`) or using a character literal (e.g. `'A'`).

To send more than one character, use the `comPrint` function.

comPrint

void comPrint (u8 comCh, char* comString[, arg0, ..., argn])

comCh : Channel number

comString : String of characters to transmit

Transmits a string of characters, *comString*, on channel *comCh*.

```
#include "moacon500.h"
void cmain(void)
{
   openCom(0, 115200, C8N1);      // Channel 0, 115200 Baud,
                                  // data bits: 8, no parity, stop bits: 1

   while (1)                      // Repeat forever
   {
       delay(500);                // Wait for 500ms
       comPrint(0, "abc\r\n");    // Transmits "abc" and a new line
   }
}
```

comString can be specified as a string literal by surrounding text in quotes. In the example above, "`abc`" is the text, and "`\r\n`" are carriage return and new line characters respectively so each "`abc`" appears on a new line.

Like the `printf` function `comPrint` may optionally contain format specifiers that are substituted by the additional arguments (*arg0,…, argn*).

```
comPrint(0, "2 + 1 = %d", 2+1);     // Transmits "2 + 1 = 3" on channel 0
```

comGet

short comGet (u8 comCh)

comCh : Channel number

returns 0~0xFF if successful, and -1 (0xFFFF) otherwise

Reads a sing character from the receive buffer for channel *comCh*. Bytes received are stored in a 255-byte receive buffer. `comGet` reads from this buffer one byte at a time. The `comLen` function can be used to see if there is any data in the receive buffer.

The following program echoes received data back to the sender one byte at a time.

```
#include "moacon500.h"

void cmain(void)
{
    short c;
    openCom(0, 115200, C8N1);     // Channel 0, 115200 Baud,
                                  // data bits: 8, no parity, stop bits: 1

    while (1)                     // Repeat forever
    {
        if(comLen(0) > 0)         // if data exists in the receive buffer
        {
            c = comGet(0);        // Get one byte
            comPut(0,c);          // Send byte back to sender
        }
    }
}
```

comGetInterval

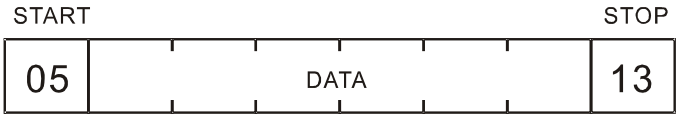
u8 comGetInterval (u8 comCh)

comCh : Channel number

returns the time interval in milliseconds between packets

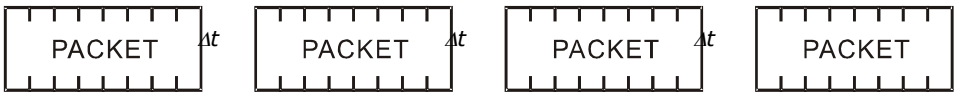
Gets the time interval in milliseconds between packets of data received on channel *comCh*.

Often packets of data are sent wrapped in a start and stop code, and therefore, when parsing data, it is easy to know when all data has been received.



However, one problem with this approach is the start and stop codes cannot be used in the data (payload) unless they are escaped.

To get around this limitation, some protocols separate packets by intervals of time (Δt). Modbus RTU is one example of this method.



`comGetInterval` is needed to implement this kind of protocol. When a packet of data arrives in the receive buffer, `comGetInterval` will return the amount of time in milliseconds that has elapsed between when data was removed from the receive buffer and when data arrived in the receive buffer (up to 255ms).

To accurately measure the time between packets, packets should be removed from the receive buffer immediately when they arrive.

```
#include "moacon500.h"

void cmain(void)
{
    u8 deltaT = 0;
    char c[64];
    openCom(0, 115200, C8N1);     // Channel 0, 115200 Baud,
                                  // data bits: 8, no parity, stop bits: 1

    while (1)                     // Repeat forever
    {
        if(comLen(0) >= 64)       // if data exists in the receive buffer
        {
           deltaT = comGetInterval(0); // Time since last packet was received
           comGets(0, c, 64);          // Remove data from receive buffer
        }
    }
}
```

In the program above, `comGets` is used to remove data from the receive buffer as it arrives. `comGetInterval` will report the amount of time in milliseconds since the last `comGets` function call.

comLen

u16 comLen (u8 comCh)

comCh : Channel number

Gets the amount of data in receive buffer for channel *comCh*.

If data is not taken out of the receive buffer with functions like `comGet`, and the receive buffer is filled, any additional incoming data will be discarded. To avoid losing incoming data, be sure to read data as it arrives.

comFlush

void comFlush (u8 comCh)

comCh : Channel number

Clears the receive buffer for channel *comCh*.

comGets

short comGets (u8 comCh, u8* dest, u16 length)

comCh : Channel number
dest: Pointer to where data that is read should be stored
length: The amount of data (in bytes) to read.
Returns –1 if data is read; 0 if data is not read.

Reads *length* bytes from the receive buffer on channel *comCh*, and stores the data in memory at address *dest*.

```
#include "moacon500.h"

void cmain(void)
{
    char c[64];
    openCom(0, 115200, C8N1);     // Channel 0, 115200 Baud,
                                  // data bits: 8, no parity, stop bits: 1

    while (1)                     // Repeat forever
    {
        if(comLen(0) > 0)         // if data exists in the receive buffer
        {
           comGets(0, c, 64);     // Read data from receive buffer in store it
                                  // and store it in char array, c.
        }
    }
}
```

The example program above reads data from the receive buffer as it arrives and stores it in char array `c`.

comPuts

void comPuts (u8 comCh, u8* src, u16 length)

comCh : Channel number
src: Pointer to data that should be sent
length: The amount of data (in bytes) to send.

Transmits *length* bytes of data from memory address *src* out channel *comCh*.

```
#include "moacon500.h"

void cmain(void)
{
    char* c = "Hello World!";
    openCom(0, 115200, C8N1);     // Channel 0, 115200 Baud,
                                  // data bits: 8, no parity, stop bits: 1

    while (1)                     // Repeat forever
    {
        comPuts(0, c, 5);         // Transmits "Hello" on channel 0
    }
}
```

The example program above prints 5 characters, "Hello", from the string stored at address c.

comPower

void comPower (u8 onoff)

onoff: 0=off, 1=on

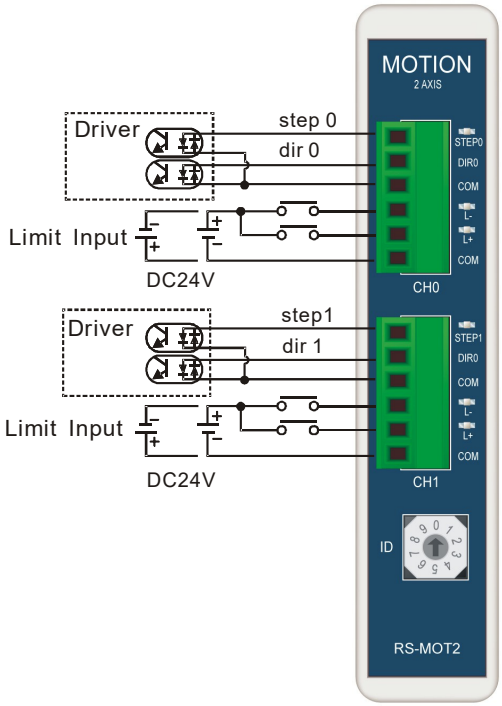
Turns the 5V power to RS-232 channel 0 on or off.

MEMO

Chapter 8
Motion Control Module

2-Axis Motion Control Module

The Motion Control Module is a 2-Axis, pulse output, stepper motor control module.



STEP and DIR are DC 5V output signals.

STEP is a pulse signal used to control the speed of the motor. It cannot drive a motor and is intended to be used by a motor driver rather than the motor itself

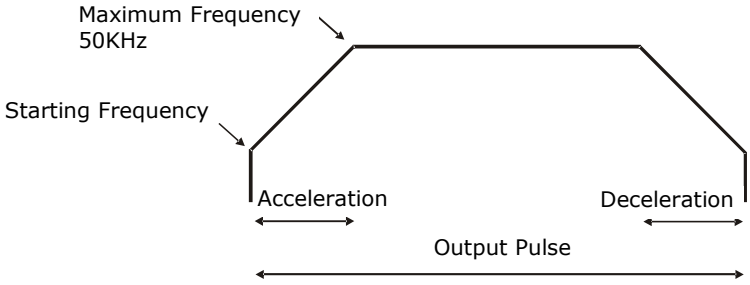
DIR is the signal used to control the direction of rotation. It, too, cannot drive a motor and is intended to be used by a motor driver. (CW – 5V, CCW – 0V)

LIMIT is the signal used for stopping the motor. When the LIMIT signal is received, STEP is stopped immediately.

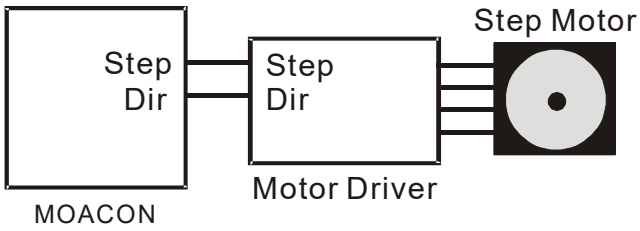
Each channel has two limit inputs that should be supplied with DC 24V

Up to 10 Motion Control Modules can be installed in a single system by giving each module a unique ID using the rotary switch on the face of the module. With the ability to install up to 10 Motion Control Modules in a single system, and each module providing 2 channels, up to 10 independent motion controllers can be used simultaneously.

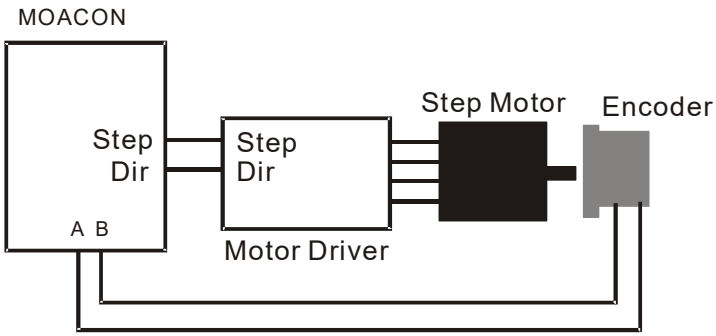
The Motion Control Module can create an accelerating pulse up to 50KHz.



To drive a stepper motor, a separate motor driver is needed. In general, there are two types of motion control systems: Open-loop systems and closed-loop systems. Closed-loop systems receive feedback from the motor about the motor's current speed, while open-loop systems receive no feedback from the motor.

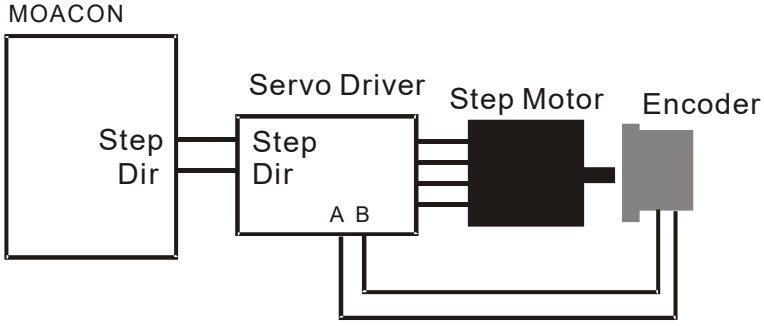


Open-Loop System



Closed-Loop System (Moacon controlled)

It is possible to implement a closed-loop system with the MOACON using the High-Speed Counter Module as shown in the figure above, but this approach is not recommended because the MOACON likely cannot be solely dedicated to monitoring the motor's movement. Therefore, an external closed-loop motion control system, as shown below, is recommended.



Closed Loop System (External to the Moacon)

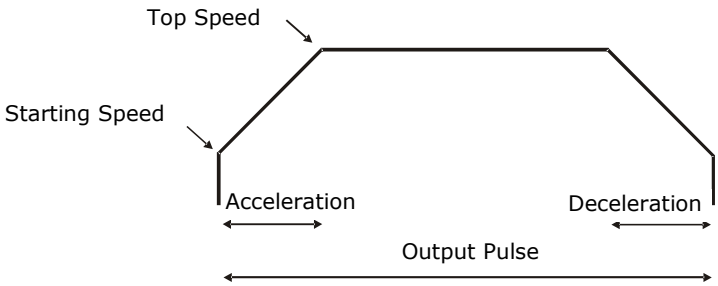
2-Axis Motion Control Library

motorSetup

void motorSetup (u8 motionID, u8 stCh, u32 freqBase, u32 freqTop, u32 stepAccel)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)
freqBase: The starting frequency (speed) in Hz to be sent to the motor driver (maximum: 50KHz).
freqTop: The top frequency (speed) in Hz to be sent to the motor driver.
freqAccel: The acceleration/deceleration in Hz/sec to be sent to the motor driver.

Sets the starting speed, top speed, and acceleration/deceleration that the motor should use when the motor starts and stops. The motor is identified by the id of the Motion Control Module, *motionID*, and the module's channel, *stCh*.



motorMove

void motorMove (u8 motionID, u8 stCh, u32 position)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)
position: The position, in steps, to move the motor to.

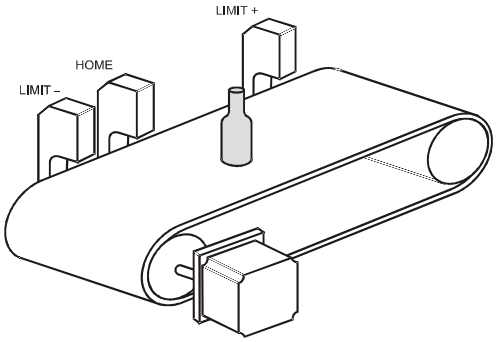
Moves the motor specified by *motionID* and *stCh* to the specified position. If *position* is the same as the current position, the motor will not move. If *position* is less than the current position, the motor will move backwards. If *position* is greater than the current position, the motor will move forward. The current position can be set to 0 using the `setMotorPos` function.

setMotorPos

void setMotorPos (u8 motionID, u8 stCh, u32 position)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)
position: The value of the motor's current position

Sets the motor's current position to *position*. The motor's starting position (home) can be set by moving the motor to it's home and calling `setMotorPos` with *position* equal to 0. This method essentially calibrates the motor to its position in the physical world. The motor is identified by id of the Motion Control Module, *motionID*, and the module's channel, *stCh*.



It is recommend that this function be called at least once when the system is powered on or initialized.

getMotorPos

u32 getMotorPos (u8 motionID, u8 stCh)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)
returns the motor's current position

Gets the motor's current position. The motor is identified by id of the Motion Control Module, *motionID*, and the module's channel, *stCh*.

motorStop

void motorStop (u8 motionID, u8 stCh)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)

Immediately terminates any pulses being sent to the motor, stopping the motor's movement. The motor is identified by id of the Motion Control Module, *motionID*, and the module's channel, *stCh*.

motorStat

u32 motorStat (u8 motionID, u8 stCh)

motionID : The ID of the Motion Control Module
stCh: The channel on the Motion Control Module (0 or 1)
returns the number of pulses left to send to the motor.

Returns the number of pulses left to send to the motor from the last call to `motorMove`. The motor is identified by id of the Motion Control Module, *motionID*, and the module's channel, *stCh*.

When `motorMove` is called, the Motion Control Module sends a stream of pulses that cause the motor to move. `motorMove` essentially tells the Motion Control Module how many pulses to send in total. If the stream of pulses is rather long and/or the wavelength of the pulse (the motor's speed) is rather slow, it may take some time for the motor to arrive at its final position. `motorStat` can be used to determine if the motor is moving and/or how much longer the motor has left to move by returning how many pulses the Motion Control Module has left to send.

The following program moves a motor to position 100,000, waits for the movement to finish, and then moves the motor back to its starting position.

```
#include "moacon500.h"

//Waits for motor to finish moving
void motorWaitToFinish(u8 motionId, u8 stChannel)
{
    //Get the current number of pulses left to send
    u32 pulseCount = motorStat(motionId, stChannel);

    //While there are still pulses remaining
    //(i.e. the motor is still moving)
    while(pulseCount > 0)
    {
        //Get the current number of pulses left to send
        pulseCount = motorStat(motionId, stChannel);

        //Print the number of pulses remaining to the debug console
        printf("%d pulses remaining\r\n", pulseCount);

        delay(500);   //Give the CPU a break.
     }
}

void cmain(void)
{
     motorSetup(0, 0, 500, 5000, 1000);  //Initialize the motor
     setMotorPos(0,0,0);         //Current position is starting position

     motorMove(0,0,100000);      //Move the motor to position 100,000
     motorWaitToFinish(0,0);     //Wait for the motor to finish moving

     motorMove(0,0,0);           //Move motor back to starting position
     motorWaitToFinish(0,0);     //Wait for the motor to finish moving
}
```

Chapter 9
Analog Modules

AD Input Module

There are 3 AD input modules: RS-ADIN4 is a low resolution module, and RS-HADIN4 is a high resolution module, and RS-SADIN6 is a high-speed module.

Module Name	Output Value	Resolution	Precision	Conversion Speed
RS-ADIN4	0 ~ 10,000	13.3-bit	±0.1%	30ms per channel
RS-HADIN4	0 ~ 100,000	16.6-bit	±0.1%	240ms per channel
RS-SADIN6	0 ~ 4095	12-bit	±0.1%	< 100μs per channel

RS-ADIN4, RS-HADIN4 Specifications	
Operating Temperature	-10 ~ 50 °C (no condensation)
Operating Humidity	35 ~ 85%RH
Input Resistance	590KΩ
Input Voltage Range	1~5V mode: 0.5 ~ 5.5V (Damage may occur if used in excess of this range) 0~10V mode: -0.5 ~ 10.5V (Damage may occur if used in excess of this range)
Communication Method	RS-485
Packet Transmission	3ms
Isolation Method	No Isolation

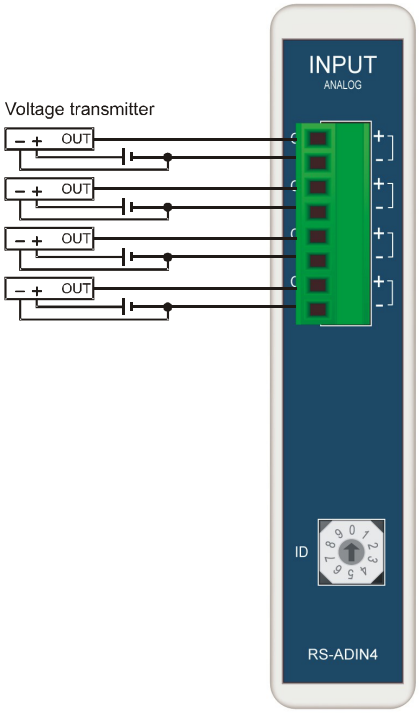
RS-SADIN6 Specifications	
Operating Temperature	-10 ~ 50 °C (no condensation)
Operating Humidity	35 ~ 85%RH
0~5V Input Impedance	450kΩ
Maximum Input Voltage	0 ~7V (voltages outside of this range risk damage)
Communication Method	RS-485
6-Channel Conversion Speed	6ms
Isolation Method	No Isolation

The AD Input Modules' inputs are not isolated, so please be sure not to provide voltage or current in excess of the specified ranges. Doing so could cause permanent damage.

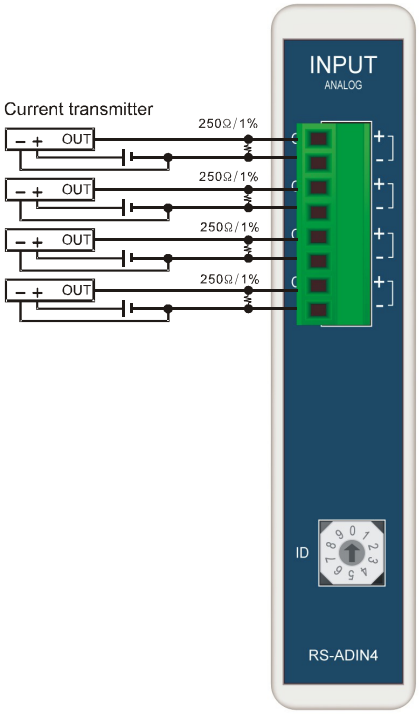
RS-ADIN4, RS-HADIN4 Analog Input Module

The AD Input Modules can be wired to read voltage sources or current sources. When reading voltages sources, the modules can be configured for a 0 ~ 10V range or a 1 ~ 5V range using the dipswitch on the side of the module. When reading a current source (4-20mA), connect a 250Ω resister across the input terminals.

Reading a voltage source (0~10V, 1~5V)

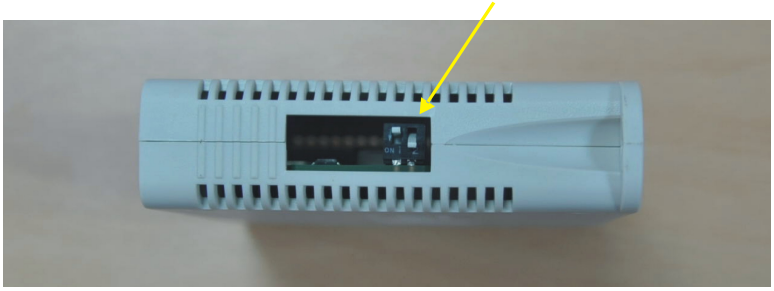


Reading a 4-20mA Current Source



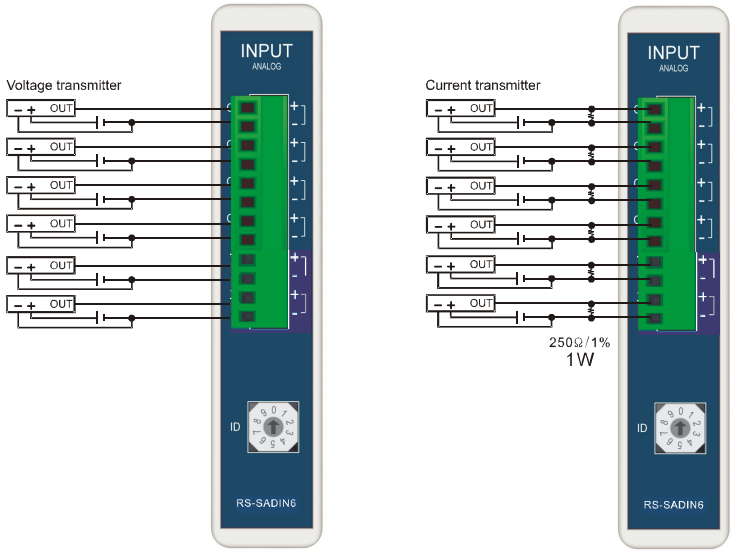
The input voltage range can be adjusted using dipswitch #2. Dipswitch #1 is not used.

Dipswitch #2 ON: 0 ~ 10V
Dipswitch #2 OFF: 1 ~ 5V



RS-SADIN6 6-Channel 12-bit Analog Input Module

The RS-SADIN6 is a high-speed, 6-channel, 12-bit analog-to-digital conversion module capable of reading all 6 channels in approximately 6ms. Switching between voltage and current readings does not require a separate dipswitch. To read current ranges from 0 ~ 20mA, simply connect a 250Ω (1% tolerance) across the + and - input terminals.



AD Input Module Library

getAdc

int getAdc (u8 adcId, u8 adcCh)

adcId : The ID of the AD Input Module (0 ~ 9)
adcCh: The channel on the AD Input Module (1 ~ 4)
returns the digitally converted value read from the ADC

Gets the digitally converted value from analog-to-digital converter (ADC) on AD Input Module *adcId*, channel *adcCh*. `getAdc` is for the RS-ADIN4 module. The module ID, *adcId*, is set using the rotary switch on the module's face.

Dipswitch #2	Return Value	Exceptions
ON (0 ~ 10V)	Value between 0 and 10,000	Open Circuit: 310 ~ 320
OFF (1 ~ 5V)	Value between 0 and 10,000	Below 0.8V: 11,111 Above 5.2V: 55,555 Open Circuit: 11,111

```
#include "moacon500.h"

void cmain(void)
{
    int voltage;
    while(1)                        //Run forever
    {
        voltage = getAdc(0, 1);     //Read from the ADC (Module 0, Channel 1)
        printf("%d\r\n", voltage); //Print value to the debug console
        delay(100);                 //Wait for 100ms
    }
}
```

getHadc

int getHadc (u8 adcId, u8 adcCh)

adcId : The ID of the AD Input Module (0 ~ 9)
adcCh: The channel on the AD Input Module (1 ~ 4)
returns the digitally converted value read from the ADC

Gets the digitally converted value from analog-to-digital converter (ADC) on AD Input Module *adcId*, channel *adcCh*. `getHadc` is for the RS-HADIN4 module. The module ID, *adcId*, is set using the rotary switch on the module's face.

Dipswitch #2	Return Value	Exceptions
ON (0 ~ 10V)	Value between 0 and 100,000	Open Circuit: 3100 ~ 3200
OFF (1 ~ 5V)	Value between 0 and 100,000	Below 0.8V: 111,111 Above 5.2V: 555,555 Open Circuit: 111,111

getSadc

int getSadc (u8 adcId, int * array)

adcId : The ID of the AD Input Module (0 ~ 9)
array: A pointer to an array of 6 integers to store the values of each channel
returns 0 if successful, -1 if unsuccessful.

Reads the digitally converted values (all 6 channels) from Analog Input module *adcId*, and stores the values in *array*. `getSadc` is for the RS-SADIN6 module. The usage differs slightly `getAdc` and `getHadc`, as all channels can be read with one function call.

```
    int sAdcData[6];
    aj = getSadc(0,sAdcData);
```

If reading fails, whether due to a wrong module ID or other factors, -1 is returned. If reading is successful, 0 is returned.

```
#include "moacon500.h"
void cmain(void)
{
    int sAdcData[6];
    u16 aj;
    while (1) {
          aj = getSadc(0,sAdcData);
          delay(500);
          printf("sadin ch1 = %x \r\n",sAdcData[0]);
          printf("sadin ch2 = %x \r\n",sAdcData[1]);
          printf("sadin ch3 = %x \r\n",sAdcData[2]);
          printf("sadin ch4 = %x \r\n",sAdcData[3]);
          printf("sadin ch5 = %x \r\n",sAdcData[4]);
          printf("sadin ch6 = %x \r\n",sAdcData[5]);
          }
}
```

Data is copied to *array* in increasing order from channel 1 to channel 6. In the example above, channel 1's value is stored in `sAdcData[0]` and channel 6's value is stored in `sAdcData[5]`.

AD Input Module's Sampling Frequency

The RS-ADIN4's sampling frequency is 30ms per channel, so sampling all 4 channels will take 120ms. Therefore, it is unnecessary to perform call `getAdc` faster than 120ms, as it will always return the same value.

The `getAdc` function call takes approximately 3ms.

The RS-HADIN4's sampling frequency is 240ms per channel, so sampling all 4 channels will take approximately 960ms. Therefore, it is also unnecessary to call `getHadc` at a rate greater than 960ms, as it too will always return the same value.

When the system is first powered on, all four channels are scanned once. Calling `getAdc` or `getHadc` at this time will return an invalid value. When using the RS-ADIN4 module, please allow at least 120 ms from the time the system is powered on before calling `getAdc`. Similarly, when using the RS-HADIN4 module, please allow at least 960ms from the time the system is powered on before calling `getHadc`.

The RS-SADIN6's sampling frequency is the fastest of all analog input modules at 10s of microseconds. There is no need to wait for sampling before calling `getSadc`.

AD Input Module's Internals

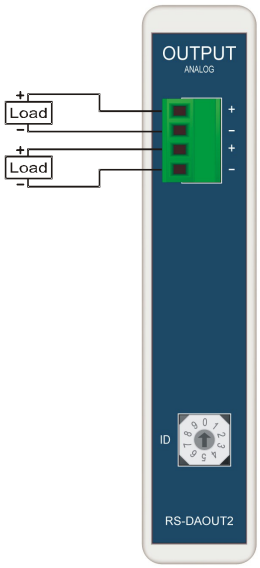
The AD Input Modules have built in low pass filter and noise canceling circuitry. Since the A/D pins are not exposed, the user is not expected to design additional circuitry.

In addition, the AD Input Modules have their own dedicated microcontroller for performing the conversion, so they do not have to rely on the MOACON's CPU. Conversion is performed by the AD Input Module itself and the `getAdc`/`getHadc` functions just read the results.

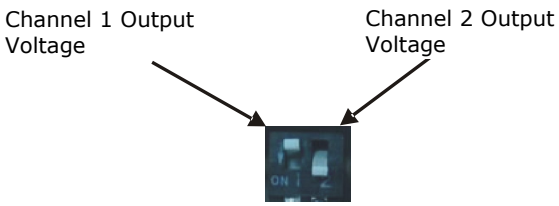
The RS-HADIN4 has the benefit of a higher resolution using Voltage-to-Frequency chips, but takes longer to do the conversion. Therefore, the RS-HADIN4 may not be suitable for high frequency signals.

DA Voltage Output Module

The DA Voltage Output Module is a 2-channel, 0 ~ 5V / 0 ~ 10V digital-to-analog voltage converter module. The voltage range is configured using the dipswitch on the side of the module.



Dipswitch Configuration



OFF: 0 ~ 10V
ON : 0 ~ 5V

RS-DAOUT2 Specifications	
Analog Output	DC 0~5V Or 0~10V (1KΩ or higher load)
Operating Temperature	-10 ~ 50 °C (no condensation)
Operating Humidity	35 ~ 85%RH
Output Resolution	0 ~ 60,000
Communication Method	RS-485
Maximum Conversion Rate	0 ~ 60,000, 600ms
Isolation Method	No Isolation

dacOut

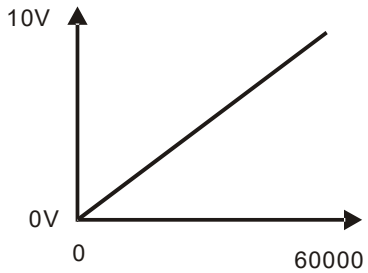
void dacOut (u8 dacId, u8 dacCh, u16 daValue)

dacId : The ID of the DA Output Module (0 ~ 9)
dacCh: The channel on the DA Output Module (1 ~ 2)
daValue: The output magnitude (0 ~ 60,000)

Sets the output of the digital-to-analog converter (DAC) on DA Voltage Output Module *dacId*, channel *dacCh*. *daValue* is the magnitude of the output voltage represented as a number between 0 and 60,000.

Up to 10 DA Voltage Output Modules can be installed in a single system providing a total of 20 DA output channels.

daValue corresponds linearly to the output voltage (0 ~ 10V, dipswitch OFF / 0 ~ 5V dipswitch ON).



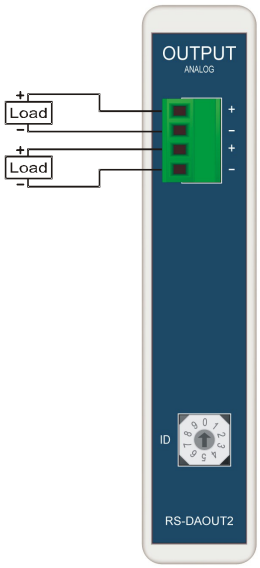
Output load should be at least 1KΩ.

The following sample program slowly increases the voltage from 0 to 10V, 1V at a time.

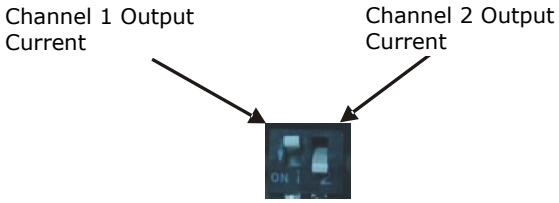
```
#include "moacon500.h"

void cmain(void)
{
    while(1)                          //Run forever
    {
        u16 v = 0;
        for(v = 0; v<60000; v+=6000) //Increase by 1V(6000) until 10V(60000)
        {
            dacOut(0,2,v);            //Set output voltage
            delay(1000);              //Wait for 1 second
        }
    }
}
```

DA Current Output Module

The DA Current Output Module is a 2-channel 0 ~ 20mA / 4 ~ 20mA digital-to-analog current converter module. The current range is configured using the dipswitch on the side of the module.



Dipswitch Configuration



OFF: 4 ~ 20mA
ON : 0 ~ 20mA

RS-DAOUT2B Specifications	
Analog Output	0~20mA Or 4~20mA (600Ω or higher load)
Operating Temperature	-10 ~ 50 °C (no condensation)
Operating Humidity	35 ~ 85%RH
Output Resolution	0 ~ 60,000
Communication Method	RS-485
Maximum Conversion Rate	0 ~ 60,000, 600ms
Isolation Method	No Isolation

dacOut2

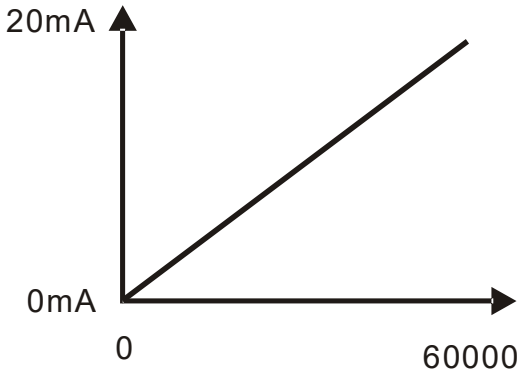
void dacOut2 (u8 dacId, u8 dacCh, u16 daValue)

dacId : The ID of the DA Output Module (0 ~ 9)
dacCh: The channel on the DA Output Module (1 ~ 2)
daValue: The output magnitude (0 ~ 60,000)

Sets the output of the digital-to-analog converter (DAC) on DA Current Output Module *dacId*, channel *dacCh*. *daValue* is the magnitude of the output current represented as a number between 0 and 60,000.

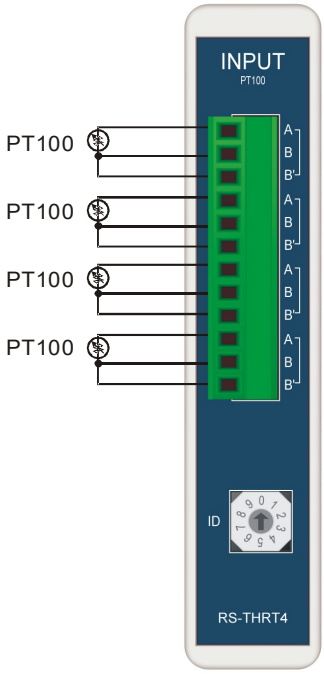
Up to 10 DA Current Output Modules can be installed in a single system providing a total of 20 DA output channels.

daValue corresponds linearly to the output current (4 ~ 20mA, dipswitch OFF / 0 ~ 20mA, dipswitch ON).



Temperature Input Module

The Temperature Input Modules, used with a PT100Ω temperature sensor, can measure temperatures between −100 and 500 °C with a precision of ±0.5%.



RS-THRT4 Specifications	
Operating Temperature	-10 ~ 50 °C (no condensation)
Operating Humidity	35 ~ 85%RH
Sampling Rate	200ms per channel
Input	RTD Sensor (PT100)
Allowable Line Resistance	10Ω or less per line from the module to the temperature sensor
Precision	±0.5%
Communication Method	RS-485
Packet Transmission Rate	3ms
Isolation Method	No Isolation

Temperature Input Module Library

getTemp

int getTemp (u8 tempId, u8 tempCh)

tempId : The ID of the Temperature Input Module (0 ~ 9)
tempCh: The channel on the Temperature Input Module (1 ~ 2)
returns the temperature in °C multiplied by 10. (-1000 ~ 5000)

Gets the temperature read from a PT100 sensor connected to Temperature Input Module *tempId* on channel *tempCh*.

The return value is the temperature in °C multiplied by 10. In other words if `getTemp` returns the value 205, the actual temperature is 20.5 °C.

If an error occurs, the following values may be returned.

Exception	Description
20001 ~ 20003	An error occurred while transmitting the value to the CPU
20004	Invalid module ID
20005	Sensor is not connected
55555	Value exceeds valid maximum
11111	Value is below valid minimum

The following sample program prints the temperature to the debug console every second

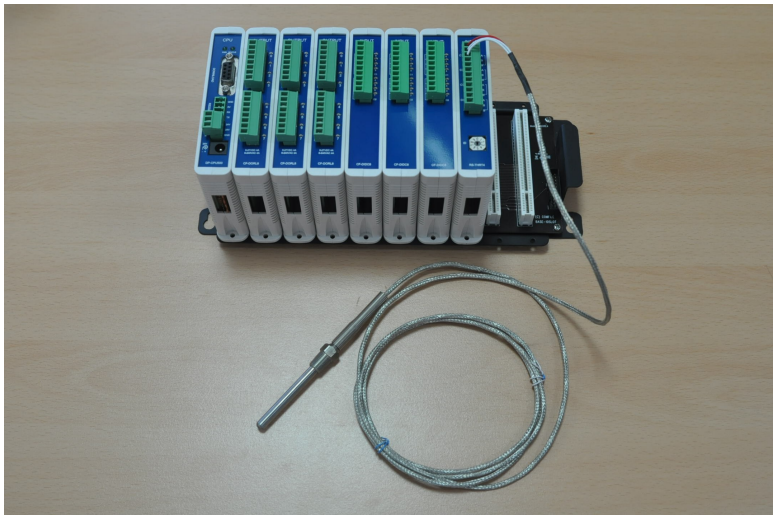
```
#include "moacon500.h"

void cmain(void)
{
    int temp = 0;
    while(1)
    {
        temp = getTemp(0, 1);       //Get the Temperature

        //Print the temperature(e.g. "Temp: 20.5")
        printf("Temp: %d.%d \r\n", temp/10, temp%10);

        delay(1000);                //Wait for 1 second
    }
}
```

The sampling rate of the Temperature Input Module is 200ms per channel, and is constantly sampling the temperature sensor. `getTemp` returns the most recently sampled value.

The Temperature Input Module samples all channels at once, so at 200ms per channel, the total sampling time for four channels is 800ms. Therefore, there is no benefit in calling `getTemp` at a rate greater than 800ms, as it will always return the same value. `getTemp`'s execution time is roughly 3ms.

When the system is first powered on, all four channels are scanned once. Calling `getTemp` at this time will return an invalid value. Please allow at least 800ms from the time the system is powered on before calling `getTemp`.

The following is an image of a PT100 temperature sensor.



Chapter 10
Ethernet Module

Ethernet Module

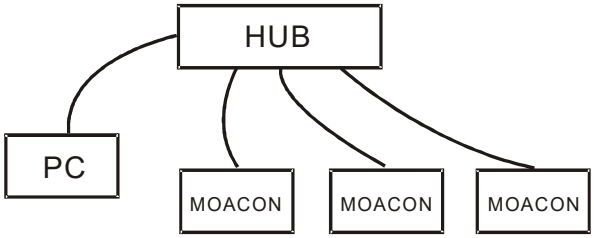
The Ethernet module provides TCP/IP capabilities to the MOACON.

LED Descriptions

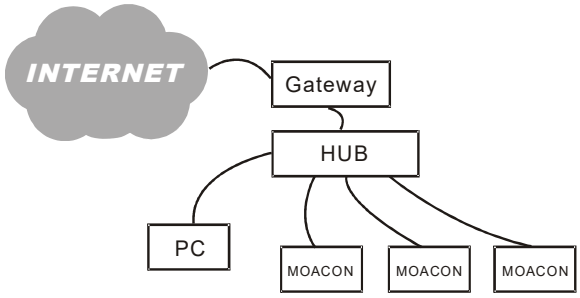
TX : Transmit
RX : Receive
ERR : Data/IP Conflict
FULL : Full duplex
100M : 100Mb Ethernet Enabled
LINK : Connection Status

Network Connectivity

Ethernet devices are usually connected to one another through a hub or switch. Each device must have a unique MAC and IP Address. The hub/switch connects all devices to each other forming a local network.



If connecting several devices to the Internet, typically they all must traverse a gateway and/or router. The gateway/router has two ports: one connected to the Internet, and one connected to the local network. The gateway/router must have one unique MAC and IP address for the Internet port, and a separate MAC and IP address for the local network port. The gateway/router then brokers data back and forth between the Internet and the local network.

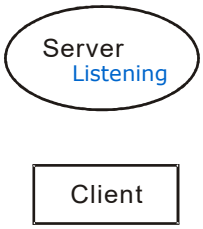


TCP Client-Server Communication

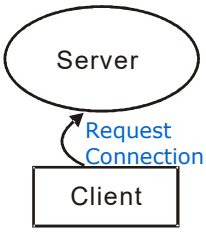
TCP Client-Server communication is the typical method in which two nodes on a network communicate with one another.

A server listens for a connection from a client. When a client connects, the server confirms the connection from the client. Once the connection is established, they can transmit and receive data to and from one another.

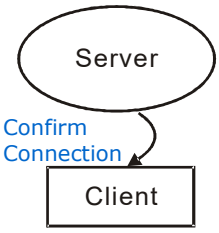
1. Server listens for connection



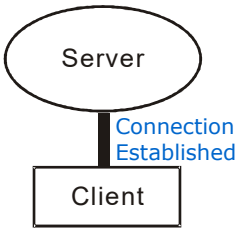
2. Client requests a connection to the server.



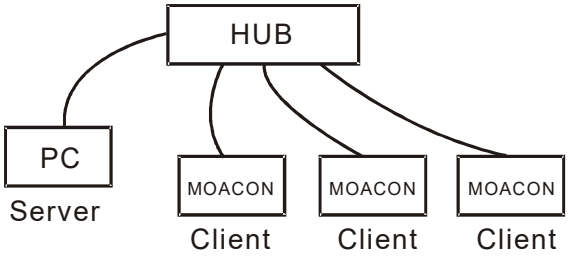
3. Server confirms the connection with the client.



4. Client and server transmit and receive data.



The following diagram illustrates how a network might look with a PC as a server, and several MOACONs as clients.



Ethernet Module Library

Network programming uses Internet Sockets which are endpoints in computer networks based on the Internet Protocol(IP). The Ethernet Module supports up to 4 sockets (0~3). Each socket holds a 2KB transmit buffer and a 2KB receive buffer for a total of 4KB per socket. Because there are 4 sockets, a total of 16KB is allocated. However, this memory is separate from the CPU, so the program's main memory is not negatively affected.

Readers are encouraged to familiarize themselves with socket programming to better understand how to use the MOACON's Ethernet Module library. There are many great socket programming resources available, so this manual will not attempt to reproduce that material here.

netBegin

void netBegin (u8* gatewayIP, u8* subnetMask, u8* macAdr, u8* deviceIp)

gatewayIP : Gateway IP address
subnetMask: Subnet mask
macAdr: MAC Address
deviceIp: IP address of the Ethernet Module

Configures the TCP/IP network settings of the Ethernet Module. The Ethernet Module does not support DHCP. The MAC address and the IP address must be unique on the network.

```
u8 GatewayIP[]={192,168,0,1};
u8 SubnetMask[]={255,255,255,0};
u8 MacAdr[]={0,0,34,53,12,0};
u8 DeviceIp[]={192,168,0,12};
u8 destIP[]={192,168,0,2};

netBegin(GatewayIP, SubnetMask, MacAdr, DeviceIp);
```

The MOACON supports the ICMP protocol, so after a call to `netBegin`, the IP settings can be tested by sending a ping command to the MOACON.

socketOpen

u8 socketOpen (u8 socketNum, u16 port)

socketNum : The socket number (0~3)
port: TCP port
Returns 1 if successful, 0 otherwise

Opens a socket, *socketNum*, on the TCP port, *port*. Port can be any number from 0 through 65,535.

NOTE: Any socket opened with a call to `socketOpen` must eventually be closed with a call to `socketClose`. The Ethernet module is not reset when the CPU module is reset, so, it may be necessary to call `socketClose` at the beginning of a program to be sure the socket is closed before it is used.

socketClose

void socketClose (u8 socketNum)

socketNum : The socket number (0~3)

Closes the socket, *socketNum*. Open sockets that are no longer needed in a program should always be closed.

listen

u8 listen (u8 socketNum)

socketNum : The socket number (0~3)
Returns 1 if successful, 0 otherwise

Listens for incoming connections on the socket, *socketNum*.

connect

u8 connect (u8 socketNum, u8* destIP, u16 destPort)

socketNum : The socket number (0~3)
destIP : The IP address of the device to connect to
destPort : The TCP port to connect to
Returns 1 if successful, 0 otherwise

Requests a connection to IP address, *destIP,* on port, *destPort,* using the socket, socketNum. The socket, *socketNum*, must first be opened using the `socketOpen` function.

```
u8 GatewayIP[]={192,168,0,1};
u8 SubnetMask[]={255,255,255,0};
u8 MacAdr[]={0,0,34,53,12,0};
u8 DeviceIp[]={192,168,0,12};
u8 destIP[]={192,168,0,2};

netBegin(GatewayIP, SubnetMask, MacAdr, DeviceIp);

socketOpen(0,82);
connect(0,destIP,5000);
```

NOTE: Any socket connect with a call to `connect` must eventually be disconnected with a call to `disConnect`. The Ethernet module is not reset when the CPU module is reset, so, it may be necessary to call `disConnect` at the beginning of a program to be sure the socket is disconnected before it is used.

disConnect

u8 disConnect (u8 socketNum)

socketNum : The socket number (0~3)
Returns 1 if successful, 0 otherwise

Terminates a connection previously established using the `connect` function. Connected sockets that are no longer needed in a program should always be disconnected.

netStatus

u8 netStatus (u8 socketNum)

socketNum : The socket number (0~3)
returns a value indicating the connection status

Gets the connection status of the socket, socketNum. Constants have already been predefined for convenience.

Value	Defined Constant	Description
0x00	SOCK_CLOSED	The socket is closed.
0x13	SOCK_INIT	The socket has been opened.
0x14	SOCK_LISTEN	The socket is listening for connections.
0x15 0x16 0x17	SOCK_SYNSENT SOCK_SYNRECV SOCK_ESTABLISHED	When a connection is being made, the two endpoints must share a series of handshaking packets with one another until the connection is finally established. When a socket is connecting, it may be in any one of these states until the connection is established.
0x18 0x1A 0x1B 0x1C 0x1D	SOCK_FIN_WAIT SOCK_CLOSING SOCK_TIME_WAIT SOCK_CLOSE_WAIT SOCK_LAST_ACK	When a connection is closed, the two connection endpoints must close in an orderly fashion sending a series of handshaking packets to one another until the connection is finally closed. When a socket is disconnecting, it may be in any one of these states until it is closed.

netSend

u8 netSend(u8 socketNum, u8* buffer, u16 length)

socketNum : The socket number (0~3)
buffer : The location of the data to send
length : The number of bytes to send
Returns 1 if successful, 0 otherwise

Sends *length* bytes of *data* in buffer out socket, *socketNum*. This function is especially useful for sending binary data. A connection must be established (SOCK_ESTABLILSHED) to send data.

```
u8 data[] = "Comfile";
netSend(0, data, 7);
```

netPrint

void netPrint(u8 socketNum, char *formatString[, arg0, ..., argn]))

socketNum : The socket number (0~3)
formatString: A character string to be printed that can optionally contain format specifiers
arg0,...,argn: An optional set of arguments to be used by format specifiers.
Returns 1 if successful, 0 otherwise

Sends a character string, *formatString*, out socket, *socketNum*. The format string can optionally contain format specifiers just like the `printf` function. A connection must be established (SOCK_ESTABLILSHED) to send data.

```
u8 lucky = 7;
netPrint(0, "%d is a lucky number", lucky);
```

netTxFree

u16 netTxFree (u8 socketNum)

socketNum : The socket number (0~3)
Returns the number of available bytes in the transmit buffer

Gets the number of available bytes in the transmit buffer for socket, *socketNum*.

When the `netSend` and `netPrint` fuctions are used, the data to be sent is stored in the socket's transmit buffer, to be transmitted by the Ethernet Module. However, the CPU is much faster than the typical Ethernet network and can sometimes fill the buffer before the Ethernet Module can transmit it on the network. Therefore, it is wise to check if there is room in the transmit buffer before calling `netSend` or `netPrint`.

The transmit buffer is 2KB(2048 bytes), so if this function returns 2048, the entire buffer is free and there is no data waiting to be sent.

netRecv

u16 netRecv (u8 socketNum, u8* buffer, u16 length)

socketNum : The socket number (0~3)
buffer : The location in memory to store the received data
length : The number of bytes to receive
Returns the number of bytes read from the receive buffer

Takes *length* bytes of data out of the receive buffer on socket, *socketNum*, and stores the data in memory location, *buffer*. A connection must be established (SOCK_ESTABLILSHED) to receive data.

To know how much data can be read from the receive buffer, use the `netRxLen` function.

netRxLen

u16 netRxLen (u8 socketNum)

socketNum : The socket number (0~3)
Returns the number of available bytes in the receive buffer

Gets the number of bytes in the receive buffer for socket, *socketNum*.

Each socket's receive buffer is 2KB (2048 bytes). To make room for more data in the receive buffer, call `netRecv`. If room is not made available in the receive buffer by the time more data arrives, the newly arrived data will be discarded.

Because there is no receive event for the Ethernet Module, a timer should be used to periodically check if data has been received.

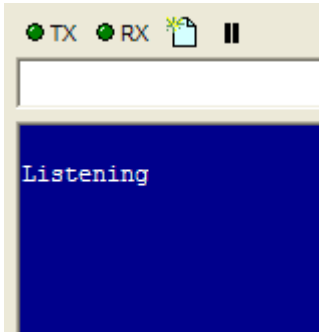
Sample Program

The following program implements a simple web server on the MOACON. It will listen on port 8080 and respond to any connection with "Hello from the MOACON."

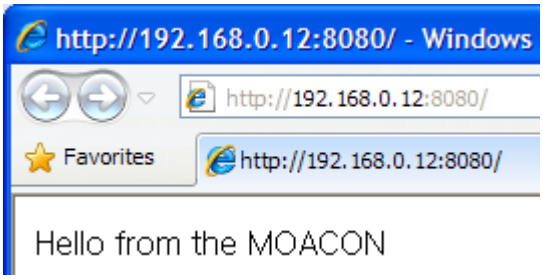
```
#include "moacon500.h"
#include <string.h>

void cmain(void)
{
 //Configure the network settings
 u8 GatewayIP[]={192,168,0,1};
 u8 SubnetMask[]={255,255,255,0};
 u8 MacAdr[]={0,0,34,53,12,0};
 u8 DeviceIp[]={192,168,0,12};
 netBegin(GatewayIP, SubnetMask, MacAdr, DeviceIp);

 //Use socket 0
 u8 socket = 0;

 //Ensure socket is disconnected and closed
 disConnect(socket);
 close(socket);

 //Keep track of the connection status
 u8 currentStatus = 0xFF;
 u8 lastStatus = 0xFF;

 while (1)   //Run forever
 {
    currentStatus = netStatus(socket);
    if (currentStatus != lastStatus)        //If connection status changes
    {
       lastStatus = currentStatus;

       switch(currentStatus)
       {
          case SOCK_INIT:        //If not listening, start listening
            printf("Init\r\n");
            socketOpen(socket,8080);
            listen(socket);
            break;

          case SOCK_CLOSED:      //If closed, start listening
            printf("Closed\r\n");
            socketOpen(socket,8080);
            listen(socket);
            break;

          case SOCK_ESTABLISHED: //If connection established, respond
            printf("Established\r\n");

            netPrint(socket, "HTTP/1.0 200 OK\r\n");
            netPrint(socket, "Content-Type: text\r\n");

            char* hello = "Hello from the MOACON";
            netPrint(socket, "Content-Length: %d\r\n\r\n", strlen(hello));
            netPrint(socket, "%s", hello);
```

```
            break;

        case SOCK_LISTEN:             //If listening, just wait
            printf("Listening\r\n");
            break;

        case SOCK_CLOSE_WAIT:         //If client disconnects, disconnect
            printf("Closing\r\n");
            disConnect(socket);
            break;

        default:
            break;
       }

        delay(10);              //Wait for 10 milliseconds
      }
   }
}
```

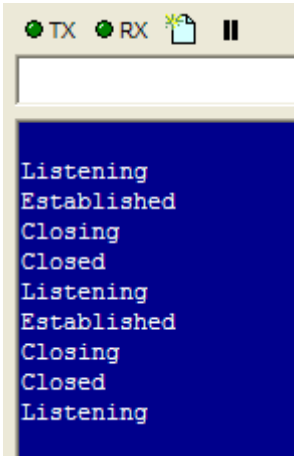
The MOACON will begin listening for connections:



Enter the URL to the MOACON socket listening on port 8080.



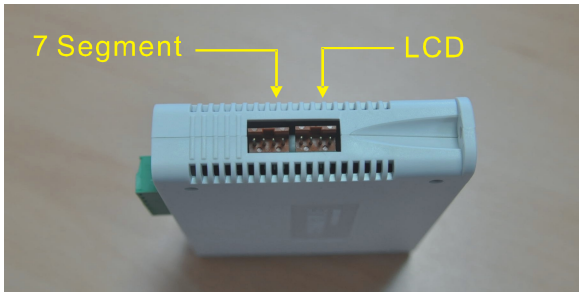
The MOACON responds and begins listening for a new connection.


TX
RX
Listening
Established
Closing
Closed
Listening
Established
Closing
Closed
Listening

Chapter 11
Display Library

Display Devices

The MOACON's CPU module includes two display ports on the side of the module for interfacing to Comfile Technology's various display devices. One port is for interfacing to Comfile Technology's 7-segment display devices (CSG-4M, CSG-4S) and the other is for interfacing to Comfile Technology's character LCD (CLCD) devices (CLCD420-B, CLSD420-G, CLCD216-G), all of which are available at www.ComfileTech.com.



CLCD and CSG devices interface cable can be up to 3 meters in length. A 1-meter cable is available at www.ComfileTech.com.

CLCD Library

The CLCD library is used to display information on Comfile Technology's CLCD devices. Each CLCD device must have a unique I2C slave address configured by a dipswitch on the back of the device. See the CLCD manual at www.ComfileTech.com for more information.

clcdI2cInit

void clcdI2cInit(u8 clcdAdr)

clcdAdr : The I2C slave address of the CLCD module

Initializes the CLCD library to use slave address *clcdAdr* for all function calls. This function must be called before any subsequent CLCD functions.

clcdUartInit

void clcdPower(u8 channel)

channel: The RS-232 channel to use

Intitializes the CLCD library to use the given RS-232 channel for all function calls.

clcdCls

void clcdCls()

Clears the CLCD screen (May take as long as 100ms).

clcdCsr

void clcdCsr(u8 onOff)

onOff : 0=Off, 1=On

Shows or hides the cursor on the CLCD module. If *onOff* is 0, the cursor is hidden; if *onOff* is 1, the cursor is shown. The default is 1 (On).

clcdPrint

void clcdPrint(u8 cx, u8 cy, char *formatString[, arg0, ..., argn])

cx: x-position (column) of first character to be printed
cy: y-position (row) of first character to be printed
formatString: A character string to be printed that can optionally contain format specifiers
arg0,...,argn: An optional set of arguments to be used by format specifiers.

Prints a character string, *formatStrng*, on the CLCD device at location *cx*, *cy*. *formatString* can contain format specifiers just like the `printf` function. See the `printf` function for more details.

clcdLocate

void clcdLocate(u8 cx, u8 cy)

cx: x-position (column) of first character to be printed

cy: y-position (row) of first character to be printed

Moves the CLCD module's cursor to the location *cx*, *cy*.

clcdBlit

void clcdBlit(u8 onOff)

onOff: 0=Off, 1=On

Turns the CLCD module's backlight on(*onOff*=1) or off(*onOff*=0).

clcdPower

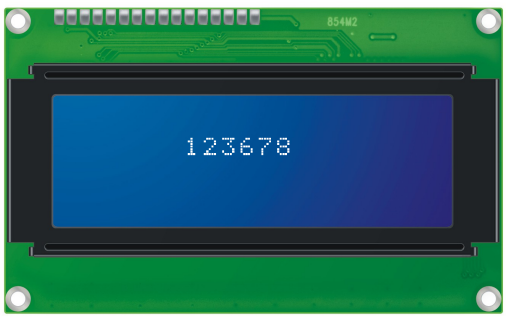
void clcdPower(u8 onOff)

onOff: 0=Off, 1=On

A 5V power source is supplied by the MOACON to the CLCD display module. This function turns the power on (*onOff*=1), or off(*onOff*=0).

The following program demonstrates how to use the CLCD library.

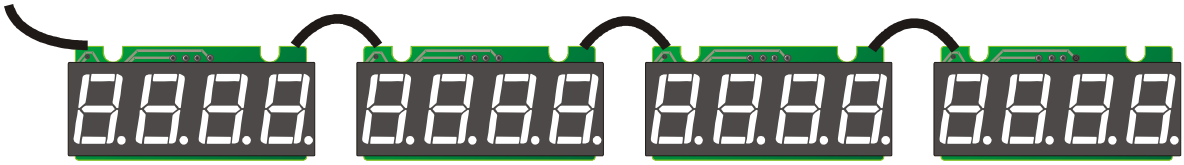
```
#include "moacon500.h"
void cmain(void)
{
    clcdI2cInit(0);                 //CLCD on slave address 0
    clcdPower(1);                   //Power on the CLCD device
    delay(100);
    clcdCls();                      //Clear the screen
   int x=123678;                   //Start counting from 123678
    while(1)                        //Run forever
    {
        delay(500);
        clcdPrint (5,1, "%d",x++);  //Print count at column 5, row 1
    }
}
```



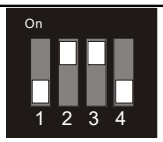
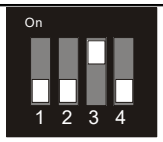
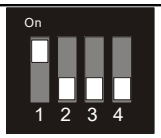
CSG Library

The CSG library is used to display information on Comfile Technology's 7-segment display devices. Each CSG device must have a unique I2C slave address configured by a dipswitch on the back of the device.

Up to 4 CSG devices can be daisy-chained together to make a longer composite display. Each device must have a different slave address.



Slave Address0 Slave Address 1 Slave Address 2 Slave Address 3

Address 0	1-Off 2-On 3-Off 4-Off	
Address 1	1-Off 2-On 3-On 4-Off	
Address 2	1-Off 2-Off 3-Off 4-Off	
Address 3	1-On 2-Off 3-Off 4-Off	

csgPrint

void csgPrint(u8 csgSlaveAdr, char *formatString[, arg0, ..., argn])

csgSlaveAdr: Slave address of the CSG device
formatString: A character string to be printed that can optionally contain format specifiers
arg0,...,argn: An optional set of arguments to be used by format specifiers.

Prints a character string, *formatStrng*, on the CSG device on address *csgSlaveAddress*. *formatString* can contain format specifiers just like the `printf` function. See the `printf` function for more details.

NOTE: CSG devices can only display ASCII characters 0x30~0x39 and 0x41-0x4F.

Examples:

```
int a = 123;
csgPrint(0, " %4d", a);
```

```
int a = 123;
csgPrint(0, "%04d", a);
```

```
int a = -123;
csgPrint(0, "%04d", a);
```

csgPrintDot

void csgPrintDot(u8 csgSlaveAdr, u8 dot0, u8 dot1, u8 dot2, u8 dot3, char *formatString[, arg0, ..., argn])

csgSlaveAdr: Slave address of the CSG device
dot0: Dot 1st from the left (0=Off, 1=On)
dot1: Dot 2nd from the left (0=Off, 1=On)
dot2: Dot 3rd from the left (0=Off, 1=On)
dot3: Dot 4th from the left (0=Off, 1=On)
formatString: A character string to be printed that can optionally contain format specifiers
arg0,...,argn: An optional set of arguments to be used by format specifiers.

Prints any or all of the 4 dots (*dot0~dot3*) on the CSG device on address *csgSlaveAddress*, along with a character string, *formatStrng*. *formatString* can contain format specifiers just like the `printf` function. See the `printf` function for more details.

Examples:

```
int a = 123;
csgPrintDot(0, 1,0,0,0, "%04d", a);
```

```
int a = 123;
csgPrintDot(0, 0,0,1,0, "%04d", a);
```

csgNput

void csgNput(u8 csgSlaveAdr, u8 csgDigit, u8 csgData)

csgSlaveAdr: Slave address of the CSG device
csgDigit: The digit location to print csgData (0~3, 0=Far Left, 3=Far Right)
csgData: The ASCII code of the character to print (0x30~0x39, 0x41-0x4F)

Prints a character, csgData, on the CSG device on address *csgSlaveAddress* in the digit location *csgDigit*. The digit location is one of the 4 digits on the CSG device with 0 being the far left and 3 being the far right. The CSG device can only display ASCII characters (0x30~0x39, 0x41-0x4F).

```
csgNput(0, 0, 0x42);  //Print the letter 'b' in the far left digit location
```

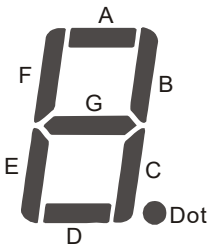
csgXput

void csgXput(u8 csgSlaveAdr, u8 csgDigit, u8 csgData)

csgSlaveAdr: Slave address of the CSG device
csgDigit: The digit location to print csgData (0~3, 0=Far Left, 3=Far Right)
csgData: A bit array with each bit corresponding to an individual LED

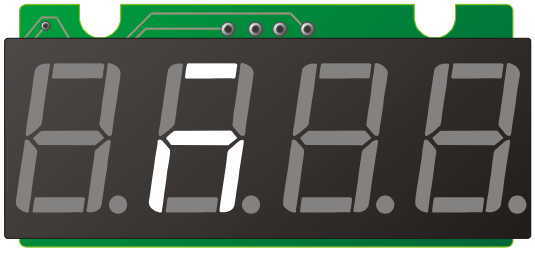
Turns on or off specific LEDs, specified by *csgData*, on the CSG device on address *csgSlaveAdr*, in digit location *csgDigit*.

csgData is a bit array in which each bit corresponds to a different LED as shown in the following table:



Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Dot	G	F	E	D	C	B	A

```
csgXput(0, 1, 0x55);  //01010101 = A,E,C,G ON; B,D,F,Dot OFF
```



Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Dot	G	F	E	D	C	B	A
	On		On		On		On

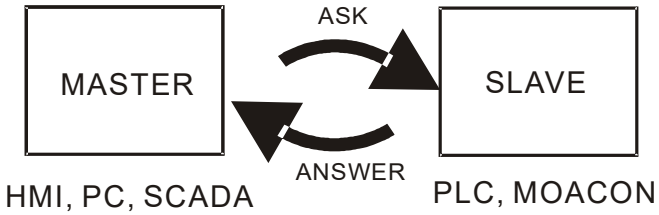
MEMO

Chapter 12
Modbus RTU

About Modbus

Modbus is a protocol created by Modicon in 1979 to communicate with industrial electronic devices, and has proliferated to become the de facto standard in the industry.

Modbus uses a request/reply protocol with a single master device and one or more slave devices. The master sends a request to a single slave, and that slave replies with a response to the master's request. A slave can only respond to requests from the master; it cannot initiate communication on its own.



Each slave has its own, unique address. The master can only communicate with one slave at a time.

These requests and replies are called frames. Modbus supports two frame formats: Remote Terminal Unit (RTU) and American Standard Code for Information Interchange (ASCII). The RTU format encodes each frame in a compact, binary form and uses a Cyclic Redundancy Check (CRC) to verify the integrity of the transmission. The ASCII format encodes each frame as a set of ASCII characters and uses a Longitudinal Redundancy Check (LRC) to verify the integrity of the transmission.

Modubus request frames vary, but typically they contain the following:

1. Slave Address – The address of the slave device the request is intended for
2. Function Code – The function to performed on the slave device (read, write, etc...)
3. Data – Information needed to perform the given function
4. Error Code – CRC for RTU, or LRC for ASCII to verify the transmission integrity

Modbus reply frames also vary, but typically they contain the following:

1. Slave Address – The address of slave device the reply is from
2. Function Code – The function performed by the slave device
3. Data – Information about the function performed
4. Error Code – CRC for RTU, or LRC for ASCII to verify the transmission integrity

This very brief introduction to Modbus is all that is needed to understand the information to follow. It is out of the scope of this document to explain Modbus in detail so, to learn more, please see The Modbus Organization.

The MOACON only supports Modbus RTU.

Modbus RTU Function Codes

The Modbus specification defines a set of function codes that specify how to read and write bits or words (16 bits). Modbus uses the term "coil" to refer to a bit, and "register" to refer to a word.

The MOACON supports the following function codes:

Function Code (Decimal)	Function	Description	MOACON Modbus Function
1	Read Coil Status	Read 1 or more bits	RTU_readCoils
2	Read Input Status	Read or more bits	RTU_readCoils
3	Read Holding Registers	Read 1 or more words	RTU_readRegs
4	Read Input Registers	Read 1 or more words	RTU_readInRegs
5	Force Single Coil	Write 1 bit	RTU_writeCoil
6	Preset Single Register	Write 1 word	RTU_writeReg
15	Force Multiple Coils	Write multiple bits	RTU_writeCoils
16	Preset Multiple Registers	Write multiple words	

In the MOACON, there is no difference between function codes 1 and 2, and there is no difference between function codes 3 and 4.

Function Code 01/02: Read Coil/Input Status

In the MOACON, function codes 1 and 2 are identical. These two functions read bit values starting at a given address.

Example Query Frame from Master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x01	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x08	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x01	1
Byte Count	0x01	1
Data 1	0x53	1
Error Check	CRC	2

The *start address* is the address of the first bit to read. *Length* is the number of bits to read, however, the response will always be in multiples of 8 bits. For example, if *length* is 5, the response will contain 8 bits. If *length* is 14, the response will be 16 bits.

Function Code 03/04: Read Holding/Input Registers

In the MOACON, function codes 3 and 4 are identical. These two functions read one ore more word (16 bits) values starting at a given address.

Example Query Frame from Master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x03	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x03	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x03	1
Byte Count	0x06	1
Data 1 (Most Significant Byte)	0x03	1
Data 1 (Least Significant Byte)	0xE8	1
Data 2 (Most Significant Byte)	0x01	1
Data 2 (Least Significant Byte)	0xF4	1
Data 3 (Most Significant Byte)	0x05	1
Data 4 (Least Significant Byte)	0x33	1
Error Check	CRC	2

The *register address* is the address of the first register to read. *Length* is the number of bytes to read.

Function Code 05: Force Single Coil

This function sets the value of a single bit at a given address.

Example Query Frame from Master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x05	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x01	1
Data (Most Significant Byte)	0xFF	1
Data (Least Significant Byte)	0x00	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x05	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x01	1
Data (Most Significant Byte)	0xFF	1
Data (Least Significant Byte)	0x00	1
Error Check	CRC	2

Start address is the address of the bit to set, and *data* is the value to set the bit to. To turn a bit ON, *data* must be 0xFF00. To turn a bit OFF, *data* must b 0x0000.

Function Code 06: Preset Single Registers

This function set the value of a single word (16 bits) at a given address.

Example Query Frame from master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x06	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x01	1
Data (Most Significant Byte)	0x12	1
Data (Least Significant Byte)	0x34	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x06	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x01	1
Data (Most Significant Byte)	0x12	1
Data (Least Significant Byte)	0x34	1
Error Check	CRC	2

Start address is the address of the word to set, and *data* is the value to set the word to.

Function Code 15: Force Multiple Coils

This function sets the value of multiple bits starting at a given address.

Example Query Frame from Master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x0F	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x10	1
Byte Count	0x02	1
Data (Most Significant Byte)	0xD1	1
Data (Least Significant Byte)	0x05	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x0F	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x10	1
Error Check	CRC	2

Start address is the address of the first bit to set, and *data* is a bit array containing the value for each bit to set. *Length* is the number of bits to set, and *byte count* is size of the data in bytes.

Function Code 16: Preset Multiple Registers

This function sets the value of multiple words (16 bits each) starting at a given address.

Example Query Frame from Master:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x10	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x03	1
Byte Count	0x06	1
Data 1 (Most Significant Byte)	0xD1	1
Data 1 (Least Significant Byte)	0x03	1
Data 2 (Most Significant Byte)	0x0A	1
Data 2 (Least Significant Byte)	0x12	1
Data 3 (Most Significant Byte)	0x04	1
Data 3 (Least Significant Byte)	0x05	1
Error Check	CRC	2

Response Frame from Slave:

	Data	Byte Count
Slave Address	0x03	1
Function Code	0x10	1
Start Address (Most Significant Byte)	0x00	1
Start Address (Least Significant Byte)	0x00	1
Length (Most Significant Byte)	0x00	1
Length (Least Significant Byte)	0x03	1
Error Check	CRC	2

Start address is the address of the first word to set, and *data* is a byte array containing the value for each byte to set. *Length* is the number of words to set, and *byte count* is size of the data in bytes.

Modbus RTU Library

startModbusRtu

void startModbusRtu(u8 comCh, u8 slaveAdr, u16* regBuffer, u16* bitBuffer)

comCh: The RS-232 channel to listen on
slaveAdr: The Modbus slave address
regBuffer: Word data memory
bitBuffer: Bit data memory

Starts a Modbus slave on the MOACON listening on RS-232 channel *comCh* with Modbus slave address slaveAdr. *regBuffer* and *bitBuffer* are the areas of memory from which the master will read and write word data and bit data respectively. These buffers **must be declared `static`**.

Because the MOACON uses the Modbus protocol over and RS-232 channel, it is necessary to open the RS-232 with the `openCom` function before calling `startModbusRtu`.

```
static u8 MDcoil[10];
static u16 MDregister[10];
openCom(2,38400, C8N1);
startModbusRtu(2,1,MDregister, MDcoil);
```

NOTE: Although the MOACON can have more than one RS-232 channel using the CPU Module and the Communication Module, the MOACON does not support multiple Modbus slaves running simultaneously.

RTU_readCoils

short RTU_readCoils(u8 comCh, u8 slaveAdr, u8* result, u16 targetAdr, u8 numOfCoils)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to read from
result: Buffer to store coil (bit) data to
targetAdr: The address of the data to read
numOfCoils: Number of coils (bits) to read
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Reads *numOfCoils* bits from slave device *slaveAdr*, at address *targetAdr*, on RS-232 channel *comCh* and stores the data in *result*. Returns a number indicating whether or not the function call was successful.

```
u8 coilBuffer[100];
res = RTU_readCoils(0,1,coilBuffer,4,12);
```

RTU_readRegs

short RTU_readRegs(u8 comCh, u8 slaveAdr, u8* result, u16 targetAdr, u8 numOfRegs)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to read from
result: Buffer to store register (word) data to
targetAdr: The address of the data to read
numOfRegss: Number of registers (words) to read
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Reads *numOfRegs* words from slave device *slaveAdr*, at address *targetAdr*, on RS-232 channel *comCh* and stores the data in *result*. Returns a number indicating whether or not the function call was successful. This function used Modbus function code 3.

```
u8 registerBuffer[100];
res = RTU_readRegs(0,1,registerBuffer,0,2);
```

RTU_readInRegs

short RTU_readInRegs(u8 comCh, u8 slaveAdr, u8* result, u16 targetAdr, u8 numOfRegs)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to read from
result: Buffer to store register (word) data to
targetAdr: The address of the data to read
numOfRegss: Number of registers (words) to read
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Performs the same operation as RTU_readRegs but uses Modbus function code 4. The MOACON does not distinguish between function codes 3 and 4, but some PLCs do. This function is provided so the MOACON can interface properly with those PLCs that distinguish between function codes 3 and 4.

RTU_writeCoil

short RTU_writeCoil(u8 comCh, u8 slaveAdr, u16 targetAdr, u8 value)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to write to
targetAdr: The address where the data should be written to
value: Bit value (0 or 1) to write
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Writes a bit value *value* to slave device *slaveAdr*, at address *targetAdr*, on RS-232 channel *comCh*. Returns a number indicating whether or not the function call was successful.

```
res = RTU_writeCoil(0,1,0x0000,1);  //Write a 1 to slave device 1,
                                    //address 0x0000
```

RTU_writeReg

short RTU_writeReg(u8 comCh, u8 slaveAdr, u16 targetAdr, u16 value)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to write to
targetAdr: The address where the data should be written to
value: Word value to write
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Writes a word value *value* to slave device *slaveAdr*, at address *targetAdr*, on RS-232 channel *comCh*. Returns a number indicating whether or not the function call was successful.

```
res = RTU_writeCoil(0,1,0x0000,0x1234); //Write word 0x1234 to slave device
                                        //1, address 0x0000
```

RTU_writeCoils

short RTU_writeCoils(u8 comCh, u8 slaveAdr, u16 targetAdr, u8 value)

comCh: The RS-232 channel to use
slaveAdr: The Modbus slave address of the device to write to
targetAdr: The address where the data should be written to
value: Bit array to write (8 bits)
returns the status of this function call (-1=Success, 0=Timeout, 1=Data Error)

Writes an array of bits, *value,* to slave device *slaveAdr*, at address *targetAdr*, on RS-232 channel *comCh*. Returns a number indicating whether or not the function call was successful. Although function code 15 is for writing several bits, this function can write at most 8 bits.

```
res = RTU_writeCoils(0,1,0x0000,0x12); //Write bit array 0x12 to slave
                                       //device 1, address 0x0000
```

getCrc

u16 getCrc (u8* targetArray, u16 length)

targetArray: Array of bytes to compute a CRC for
length: The number of bytes in the array
returns the CRC

Computes a Modbus 16 bit CRC for an array of data *targetArray* of *length* bytes. This function is provided should it be necessary to create a custom Modbus frame to send using the RS-232 communication library functions.

```
u8 txFrame[8];
u16 crc, targetAdr, numberOfCoils;

targetAdr = 0x0000;
numberOfCoils = 1;

txFrame[0] = 1;                  //Slave address 1
txFrame[1] = 1;                  //Function Code 1
txFrame[2] = targetAdr >> 8;     //Target Address MSB
txFrame[3] = targetAdr;          //Target Address LSB
txFrame[4] = numberOfCoils >> 8; //Length MSB
txFrame[5] = numberOfCoils;      //Length LSB

crc = getCrc(txFrame, 6);        //Compute CRC
txFrame[6] = crc >> 8;           //CRC MSB
txFrame[7] = crc;                //CRC LSB
```

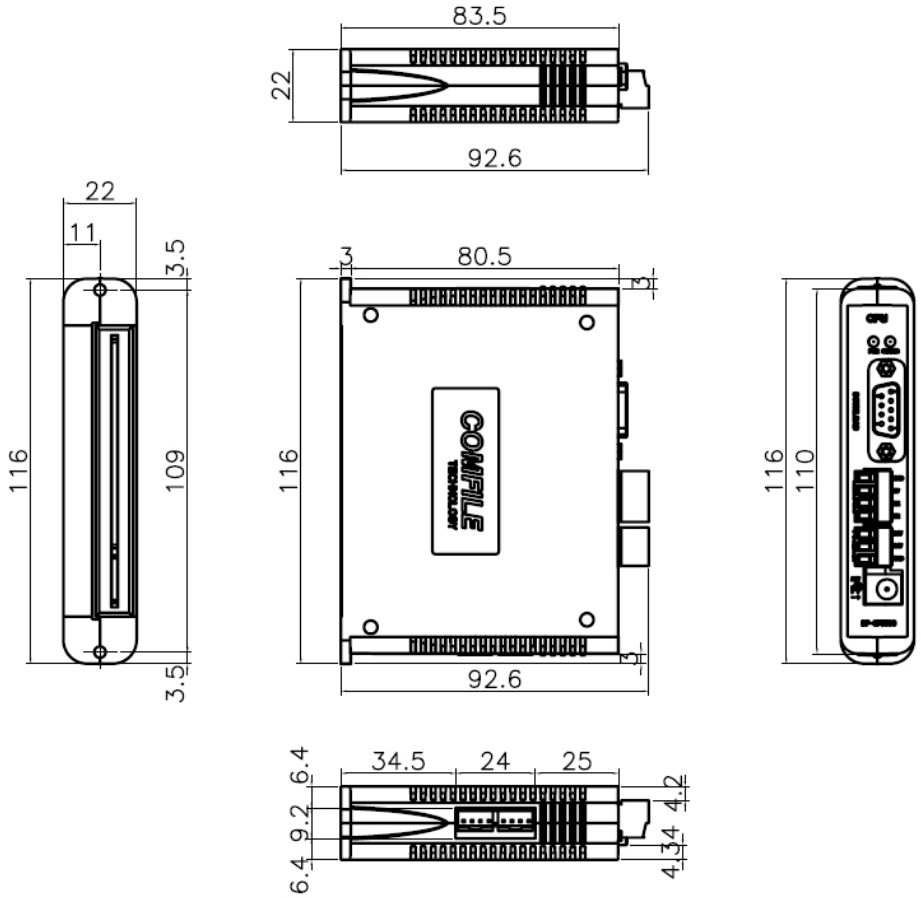
MEMO

Chapter 14
Appendix

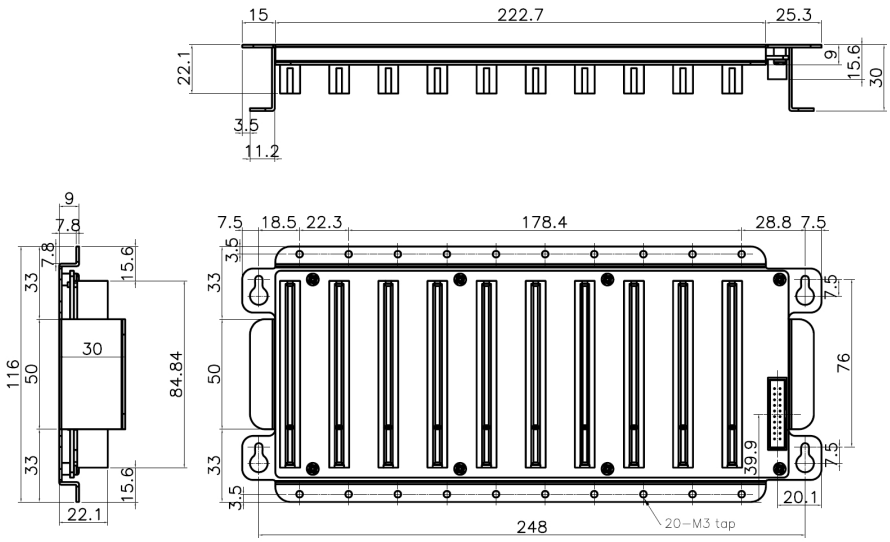
External Dimensions

All units are in millimeters (mm).

MOACON Module:



10-Slot Board:



5-Slot Board: